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TRANSACTIONS

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Volume XXXV

Edited by
P. H. GREGORY and G. C. AINSWORTH

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Edited by

P. H. GREGORY and W. C. MOORE

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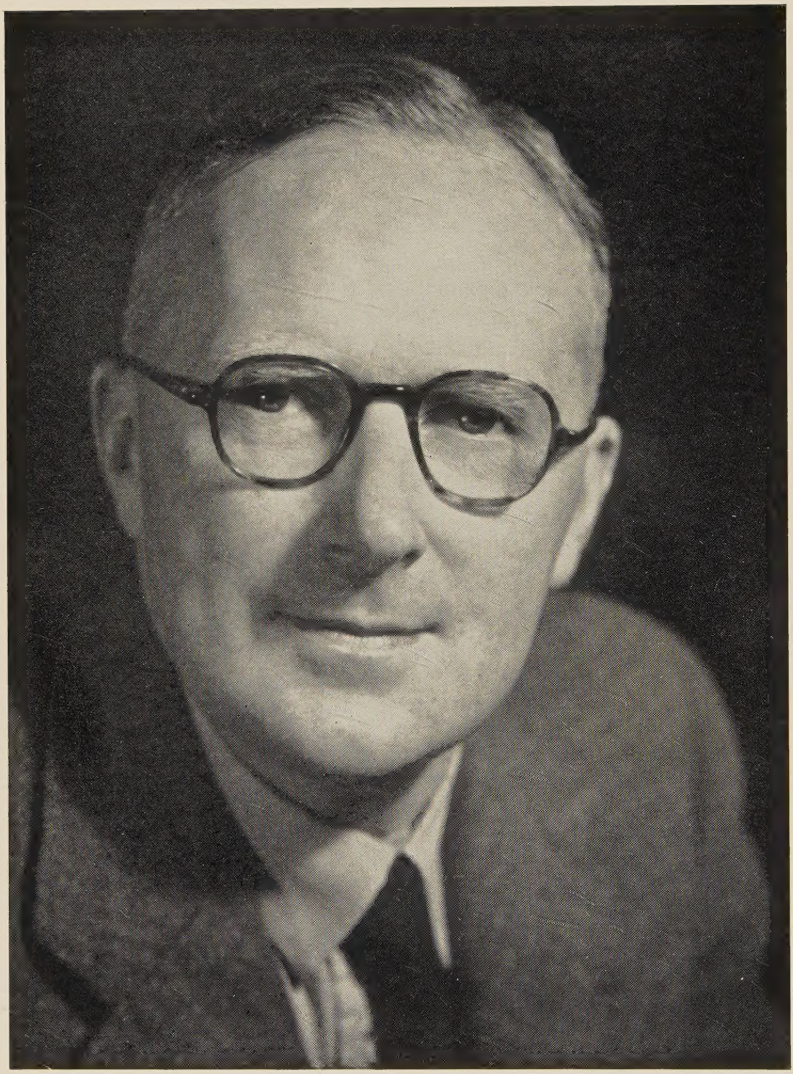

P. H. GREGORY
President, 1951

PRESIDENTIAL ADDRESS

FUNGUS SPORES

BY P. H. GREGORY, D.Sc., PH.D., F.L.S.

t this Autumn Foray, when we are celebrating the Centenary of the
other of fungus forays, the Woolhope Naturalists' Field Club, it is
ppropriate that we should turn our attention to the living fungi. Most
the specimens that we collect are still alive. Some after their imminent
eath will be given numbers, placed in herbarium cupboards and so
mmortalized, but for my part I can never accept the verdict of the
uthority on a group who stated frankly: 'these fungi are best studied
ead'. As a field mycologist I am impressed by the numerous and complex
evices associated with spore production during the varied life cycles of
e fungi. These devices are successful. How are they to be explained?

What follows is an attempt to set out a rough and ready mycological
orking philosophy. This presentation is possible because the occasion of
Presidential Address gives an opportunity for publishing opinions so
peculative that in any other form they would be rejected by a con-
ientious editor.

Three main types of explanation of activities of organisms, the phylo-
enetic, the ontogenetic and the functional, are favoured by three different
rts of people. In simple language these three explanations respectively
nswer the questions: 'Whence?', How?', and 'Why?'. The answer to the
uestion 'Whence?' explains an organ, habit or chemical substance in
rms of the evolution of the group. Thus the basidium may be explained
derived from the ascus, which, if we believe all we are told, is derived
turn from the Phycomycete sporangium. The question 'How?' explains
organ in terms of genetical, biochemical and growth processes during
e life of the individual. The ascospore is seen as the result of a long series
chemical and nuclear phenomena. The answer to the question 'Why?'
plains the organ or habit in terms of its function, if any, in the life of the
ganism. It explains that the function of the ascospore is to secure
spersal, and that the scented nectar of *Puccinia* serves to attract insects
d thus facilitates the mating of + and − strains of the rust.

At different times different types of explanation have been in fashion.
ot long ago the emphasis was on evolution, and fungus structure was
plained in terms of degeneration associated with saprophytism and
rasitism. To-day the success of biochemical exploration has changed the
mphasis to 'How?'. The question 'Why?'—explanation in terms of
nction—is under a cloud as being slightly teleological and therefore
nrespectable. We are often told that it is not the business of science to
quire 'Why?' but only 'How?'. In physical science this is probably
ue, for the subject-matter of physics is relatively simple, but in biology
believe that all three questions are legitimate and profitable. It *is* our
usiness to inquire 'Why?', because we cannot hope to understand and
ontrol an organism if we do not grasp the functions of its parts in relation

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to the life cycle of the whole. This question is peculiarly necessary with the fungi, a group of organisms in some respects unlike ourselves, because of the functions of many of their parts we have not yet the slightest idea.

Few writers on biology can resist phrases capable of teleological interpretation, phrases which in turn few reviewers can resist condemning. Biologists use these phrases presumably because they convey something that can be said in no other convenient way. Brooks and Moore (1923), discussing the invasion of woody tissue by *Stereum purpureum*, say: 'The spores of other wound parasites which infect through the wood rather than the bark, e.g. *Polyporus squamosus*, *Collybia velutipes*, etc., are universally small, so that they can readily be taken into the vessels.' Again, to quote Mather (1944): 'Although the majority of organisms agree in showing some special control over their breeding systems, whether to encourage inbreeding or outbreeding, they display a great variety of devices by which control is achieved.' Hawker (1950) writes: 'The teeth of *Hydnum* are positively geotropic...they grow vertically downwards so that the basidiospores are shed in a manner which avoids wastage.' One reviewer urges that the words 'so that' should be replaced by 'and' to read 'and the basidiospores are shed in a manner which avoids wastage'. It seems to me that this alteration misses the point, and is as unconvincing as Aaron's naive apology when asked how he came to make the golden calf—'I cast it [the gold] into the fire, and there came out this calf'.

The species have these characters because they are useful—we find this idea permeating biological writing, though often disguised for fear of the accusation of teleology. It is worth while examining this skeleton in the biological cupboard to see if it can be made presentable. The right of biologists to seek a so-called teleological explanation has recently been defended by Wilkie (1951) who says: 'It seems that the prejudice against teleological explanation is partly due to a supposition that it is a causal explanation.' A further source of prejudice seems to result from misinterpreting such a statement of fact as: '*Pilobolus* aims its sporangium towards the light' to mean that it *knows* it is aiming towards the light.

Whether we call it teleology or not (personally I do not), it is an observed fact that most organisms are highly and intricately adapted to future contingencies, and it is in this sense that biologists habitually say, and will continue to say: 'Our species has this habit *to* enable it to do so and so', or 'That is what this structure is *for*', and in making this statement no reference to consciousness is expressed or implied. Adaptation to certain future contingencies is an observed fact, but we do not suppose that the *future* occurrence of a contingency causes the structure or habit. Most of us now incline to some Neo-Darwinian explanation in which *past* occurrences of the contingency have selected favourable variants from a mixed population. Or we may think that the environment itself evokes the necessary characters in the organism. In any event it is the *past* occurrences of the contingency that prepare the species for future occurrences. Adaptation to the future is possible because many contingencies are regularly recurrent like the wind and the rain, the seasons, or the life cycle of a host. Adaptation is probably best developed against contingencies whose recurrence is most regular; this is well shown by the coprophilous flora of herbivorous animals. There are of course individuals or populations pre-adapted to a non-recurrent contingency such as the novel characters of a mutant host plant. But the term *pre-adaptation* seems to me to convey little more than the phrase 'Tom was lucky'.

The belief that adaptation is relevant to teleology arises from a failure to appreciate the role of natural selection acting on undirected variation. This role has been described by Fisher (1932) as 'a mechanism for generating a high degree of improbability', and Haldane (1932) has shown how rapidly a very low intensity of selection will alter the characters of a population of a diploid organism.

Forgetting the extreme plasticity of the fungi we have readily taken over into mycology the idea of vestigial organs from palaeontology and comparative anatomy of vertebrates and other diploid organisms. Analogy with vertebrate evolution suggested that the fungi carried many vestigial characters, long functionless and now serving only to lead inquiring mycologists to the true course of evolutionary history. However, most of us know how readily many haploid moulds lose pathogenicity, sporulation, antibiotics and other characters not selected for during culture on artificial media. If unused characters can be so rapidly lost, those that are retained must be suspected of having some function.

I believe that as a working hypothesis the possession of any organ, substance or character by a fungus should be taken as evidence that it has some function. Detailed investigations may sometimes make this hypothesis appear improbable, but it can never be disproved. The hypothesis that a structure is functionless stifles inquiry, while the hypothesis that it is probably functional stimulates experiment and observation.

This first struck me as a student. The pycnia of the rusts, it was then generally agreed, had no function, except perhaps to show that the rusts had descended from the Florideae. To quote a standard work of that period: 'It is now known that all of these fungal spermatia are non-functional, either sexually or asexually, and degenerate soon after their expulsion, or even while still in the spermogonium.' The negative proposition appeared to have been proved. Fortunately a vivid interest in function was fostered by A. H. R. Buller in Winnipeg. In a few decisive and simple experiments, J. H. Craigie demonstrated the function of the pycnia in *Puccinia helianthi*, and a new chapter in plant pathology opened. The number of non-viable spermatia and functionless trichogynes has now decreased, but plenty of puzzles remain.

Of course even in the fungi any particular organ may be truly vestigial, or due to the side action of some otherwise necessary gene, but as a working hypothesis this explanation has little to recommend it, except that it saves the labour of making experiments. The converse hypothesis is justified by ts results—it may not be true, but it stimulates speculation, observation and experiment. And here stress must be laid on the experiment as a safeguard against weaving elaborate functional explanation without evidence.

The functional explanation of structural characters has its severe critics. J. C. Willis (1940) writes of the Podostemonaceae (a peculiar family of flowering plants inhabiting tropical streams):

> Much or most of the evolution that had gone on,...seemed to be completely *de luxe*, for there was no need for the new forms, nor was there any adaptational niche that would suit one form only, and not also many others. It would almost seem as if, in cases like this, if not perhaps in most, *evolution must go on, whether there be any adaptational reason for it or not*....The phenomena shown by the Podostemaceae are also exactly matched...by the phenomena shown by the most completely parasitic plants, such as the Rafflesiaceae or many fungi, which, though they grow in marvellously uniform conditions, none the less show important structural differences....Such parasites as the fungi live almost entirely within the host, where the conditions must be more or less the same for all, so how did they come to develop such numbers of species with definite structural differences?

Willis's criticism cannot be ignored, but a reply can be found. It is precisely in the relatively uniform conditions within the host plant that the parasitic fungi show least differentiation. How many species of fungi should we distinguish to-day if we knew them only as mycelium within host tissue? But, take into account the structures developed on the surface of the host, a region where the studies of Ramdas (1946) and Geiger (1950) lead us to expect violent changes in the micro-climate, and we find a multitude of differential characters associated with production, liberation and dispersal of spores. These I suggest have evolved as adaptations to transport by the elements of this violent micro-climate. It is now beginning to become clear how some of these adaptations work.

I shall take for granted, then, that the main characters of a fungus are functional.

The impression of a biologist looking at the traditional classification of the fungi is that, whether or not the taxonomists have produced a natural phylogenetic arrangement, they have at any rate done a biologically sound job. The characters of Classes and Subclasses are not so much adaptations, as boundary conditions within which a large number of species exploit their environment. The boundary conditions describing the Phycomycetes, for example, include the possession of a non-septate mycelium, incapable of anastomosing. This limitation means that the solid fruit body is unattainable and they must ever remain moulds. Ascomycetes and Basidiomycetes have the advantage of septate hyphae, capable of anastomosing by hyphal fusions into a resistant three-dimensional network, opening up possibilities of developing complex reproductive structures; apothecia, perithecia, mushrooms, puff-balls, etc. In the Ascomycetes the diploid phase is typically restricted to a single cell, the ascus, and is associated with a wealth of haploid secondary spore forms. In the Basidiomycetes the possibility of a prolonged dicaryotic phase is introduced.

Coming down through taxonomic categories to the Order and Family, we find that though based on structural characters, they usually represent groups of species sharing a common mode of life: the rusts, the sooty moulds, the Laboulbeniales, Septobasidiales, Mycosphaerellaceae, Verrucariaceae, Zoopagaceae. The main generic characters in the fungi are clearly adaptational and are usually connected with mechanisms of spore dispersal, rather than with modes of nutrition or behaviour of the resting spores. Some specific characters may be due to chance (after all a spore must be some size and shape); or to drift; or to correlation with minute physiological adaptations; or they may themselves be adaptive.

Our hypothesis is that the structures of fungi are, on the whole, adaptive to the particular mode of life of the species, and the problems which restriction to this mode of life have forced it to solve. Adaptation is never perfect and the more complex a structure for a particular function and the more specialized it is, the less satisfactorily can the organism cope with unusual conditions, because extreme specialization involves some loss of all round ability.

SEDENTARY SPORES

In discussing the function of spores in the fungi we are concentrating on a stage in the metamorphosis of a living fungus. This fungus is essentially a multinucleate protoplasmic mass secreting a system of more or less septate tubes within which it moves. The fungus is the inhabitant of the mycelial network. Perhaps we too often regard the tubes themselves as the essential fungus organism, rather than as a chitin or cellulose exoskeleton, serving to shelter and canalize the fungus protoplasm during its travels. This shelter is particularly necessary in environments lacking a water film.

Sooner, or later, in most mycelia, the protoplasm withdraws from part of the vegetative mycelium and forms spores, nucleate, lacking a vacuole and often thick-walled. Biologically these are of two types, sedentary spores and dispersal spores. Sedentary spores such as chlamydospores, zygospores or oospores tide the organism over an unfavourable period, and germinate eventually more or less in the place where they were formed. Dispersal spores, such as many conidia, ascospores and basidiospores, function by making possible the colonization of new substrata or new areas. In passing, it is interesting to note that in the Phycomycetes any novelty resulting from fertilization and meiosis is to be found in the sedentary spores and so tied to the original habitat; the dispersal spore is asexual. In the Ascomycetes and Basidiomycetes any novel product of meiosis occurs in the ascospore or basidiospore, a dispersal spore dispatched to fresh fields where we may imagine any novelty is used to better advantage. In these higher fungi sedentary spores, usually not even worth naming as a form genus, are typically asexual in origin and repeat the characters of the parent mycelium. The teleutospores of rusts are typically sedentary spores but produce a migratory, possibly genetically novel, basidiospore on germination.

Little more need be said of sedentary spores here, except that they are tenacious of life, and often extremely hard to germinate. They are on the whole simple and their lives are unspectacular.

DISPERSAL SPORES

Dispersal spores, on the other hand, show a wide variety of adaptive mechanisms, knowledge of which can help us to understand and control fungus spread.

When dispersal spores are being formed, fungus protoplasm flows from the assimilative tube-system penetrating the substratum, towards the spore-producing hyphae on the surface. Here by one means or another, varying with the family or genus, the protoplasm becomes separated into nucleated, more or less rounded units, each enclosed by cell-wall material, ready for liberation at the surface of the substratum. From then on the mass of spores is subject to external forces. Animals, rain, wind, anything that comes along may help to disperse spores at random. To attribute too large a role to random forces, however, overlooks the fact that most fungi show characters which heavily bias the spores' future, favouring one particular dispersal route, and restricting others. So that although taken over a long enough period anything may happen, and probably does, one route alone is probably significant at any one stage of the life cycle. A formal classification of spore dispersal has been given by Dobbs (1942), who distinguishes active dispersal and passive dispersal. Here it is again instructive to contrast the Phycomycetes, where active dispersal, if it occurs at all, is a property of the asexual spore, with the Ascomycetes and Basidiomycetes, in which active dispersal is almost confined to the sexually produced spore (the rusts are exceptional in having active dispersal of aecidiospores as well as basidiospores). Passive dispersal in the sense of Dobbs, where the fungus has to rely on external forces for liberation as well as for dispersal, is prevalent in the asexual phase of the Mucorales, and the imperfect stages of the Ascomycetes and Basidiomycetes.

Two stages of dispersal must be recognized. Take-off or separation of the spore from the stratum where it was formed, and transport of the spore to a distance. Both these processes require energy to be supplied to the spore. This may come from a variety of agencies including the fungus itself, insects or other animals, the kinetic energy of rain drops, and the wind.

Many fungi, perhaps most, are not restricted to one or other of these mechanisms, but make the best of all worlds by possessing different spore forms specialized for different take-off and dispersal mechanisms. This fact has tended to be obscured by the practice of giving different Latin binomials to the different spore forms. Mason (1937) emphasized this when he wrote of the Ascomycetes: 'When two distinct imperfect spore forms occur in the same life history, and their respective spores are borne on quite distinct hyphae, then in the great majority of cases one is a slime spore and the other is a dry spore.' In fact the possession of alternative mechanisms seems to be the rule rather than the exception among the Ascomycetes if both ascospores and conidial states are considered. There are, for instance, such species as *Cymadothea trifolii* with actively discharged ascospores, dry-airborne conidia, and slimy pycnospores; or again the airborne ascospores and the splash-dispersed yeast-like form of *Taphrina*. In plant pathological practice it is sometimes sufficient to eliminate one only of these routes in order to bring the total rate of increase of an organism below the rate of elimination from natural causes.

It is convenient to discuss adaptations connected with the two processes of take-off and transport under each source of energy.

Active dispersal

Self motile zoospores occur in many Phycomycetes. They are all small and restricted to life in water, including films covering leaves and soil particles. In the Peronosporaceae we find an interesting transition towards a dry environment in which the zoosporangia have been modified as dry, air-borne dispersal spores, some germinating by zoospores, some by a germ tube, and some, like *Phytophthora infestans*, by either according to conditions.

Except for self-motile zoospores, and for heavy projectiles like the spore masses of *Pilobolus* and *Sphaerobolus*, fungi have to rely on external sources of energy for transport, but the initial process of spore liberation is often done under fungus power. Active spore discharge has been the subject of much classical research in mycology. Ingold (1939) has summarized the water-squirting mechanisms of *Pilobolus* and of the typical ascus; the rounding-off of turgid cells discharging the conidia of some Entomophthorales, *Sclerospora* and the aecidiospores of the rusts; the drop excretion mechanism of basidiospores; the catapult of *Sphaerobolus*; and the hygroscopic mechanisms of *Trichia*.

Dispersal by insects and other animals

Insect-dispersed spores, in which the insect supplies energy for liberation and transport, may be recognized by some or all of the following characters. Like the entomophilous pollens, they are usually relatively small and sticky as in the Phallales. They are, as pointed out by Mason (1937), one biological group of the slime-spored fungi, the Gloiosporeae of Wakefield and Bisby (1941); the other big group of slime-spored fungi being those dispersed by rain-splash described below. They are typically produced in small droplets which are often held in position by setae, as in the pycnia of rusts, and in both pycnospores *and* ascospores of *Ceratostomella ulmi*. The droplet and setae may be raised on stalks, the droplets may be sugary and strongly scented. We can hunt *Endophyllum euphorbiae-sylvaticae*, *Puccinia suaveolens*, as well as *Phallus impudicus* and *Clathrus ruber* by scent.

We know little as yet of the characteristics of dispersal by larger animals, except in such coprophilous fungi as *Pilobolus* and *Sphaerobolus* whose spores are often projected forcibly across the boundary layer of still air near the ground and deposited on vegetation where they are later eaten by animals. In hypogeous fungi, animal dispersal seems to be correlated with thick-walled, heavily warted spores, difficult to germinate (obviously they must be or they would germinate *in situ* as soon as formed). The fruit bodies are often scented.

Animals parasites commonly have sticky spores adhering on contact. I believe that some of the conidial forms of the dermatophytes are contact spores, formed either in the parasitic phase on the animal skin or in the saprophytic phase on detached epidermal fragments in moist places (Davidson & Gregory, 1937). A similar habit is found in some Zoopagaceae whose sticky conidia adhere to wandering amoebae and nematodes.

Rain-splash

The kinetic energy of raindrops is used in two different ways by Gasteromycetes. The Nidulariaceae show the splash-cup mechanism, recently described in detail by Brodie (1951) in which the peridiolum is splashed to distances up to 7 ft. Some puff-balls and earth-stars have developed the bellows mechanism in which a jet of dry spores is ejected to a height of several centimetres when the peridium is hit by a raindrop. The requirements for efficient working are that there shall be a narrow ostiole and a soft top to the peridium. Rain liberates the spores, but they do not travel in raindrops (Gregory, 1949).

The use of rain-splash for take-off is best developed in the Ascomycetes and their imperfect states. The spores may be small, as in *Phyllosticta*, or they may be long and narrow as in *Septoria*, but they are never very wide. They resemble insect-dispersed spores in being easily wetted, slime spores, and include the conidia of many of the Melanconiales, Sphaeropsidales, Tuberculariaceae and the ascospores of some Sphaeriales. When dry they are held firmly to their substratum by the mucilage in which they are embedded, and are then difficult to detach by dry air currents (Gregory, 1932; Stepanov, 1935). When rain comes the first drops wet the surface, swell the mucilage holding the spores, perhaps forcing them out of a perithecium or pycnidium, and allow them to float freely over the surface of the substratum in a film of water from which they can be removed by succeeding raindrops. To understand how this takes place reference should be made to the photographs obtained by Worthington and Cole (1897). Striking a liquid surface with a velocity of from 2 to 9 m./sec. according to its size, a raindrop causes a cup-like depression. The edge of this cup moves upwards and outwards, and becomes broken by surface tension into rays which ultimately separate into a chain of splash droplets. The droplets of each chain are of two sizes, the main droplets alternating with smaller droplets. This process occupies only a few thousandths of a second and causes a cloud of splash droplets to ascend from the place where each raindrop impacts. By dropping green ink on to a film of red ink I have shown that the resulting splash droplets consist of an intimate mixture of water from the incident raindrop with water from the surface film. Some of the spores lying in the surface film are thus carried away with the cloud of splash droplets. (Spores are not, of course, dispersed in raindrops but in the resulting splash droplets). The readiness with which spores of various shapes and sizes are picked up by splash droplets of different size and energies would make an interesting experimental study. The work of Ellison (1944) on raindrop erosion of soil shows that larger soil particles are picked up more easily in splash droplets than the smaller clay and silt particles, so it is likely that selective effects will be found when we come to study fungus spores. We know nothing of the relative ease with which splash droplets pick up spherical, filiform, straight, sickle-shaped or helical spores, or the A and B conidia of *Phomopsis*.

Once in the air, splash droplets have a trajectory depending on their size and angle of discharge from the cup. Their initial speed will soon be lost by air resistance, and after travelling for several centimetres the droplets will continue to move passively under the combined action of wind and gravity like any other airborne particle. However the droplet, being small, presents a large surface for evaporation, and will rapidly dry unless deposited on a twig or other surface near the origin. Henceforth any spore picked up by the splash droplet will continue on its way like a dry spore.

Rain-splash is limited to conditions favouring germination. On the other hand, it suffers from the disadvantage that heavy rain may wash spores off surfaces on which they have been deposited. When leaves drip in heavy dews the splash-dispersal mechanism may again operate, but under conditions totally different from rain.

Possibly splash dispersal makes it easier for a spore to rise vertically above the source than when liberated into dry air, and this may be one reason why slime-spored fungi are so important as tree and bush pathogens. The conidia of *Venturia inaequalis*, despite earlier reports to the contrary, are probably detached only when the leaf is wet.

Wind dispersal

One of the major problems solved by those land plants that rely on wind for the transport of spores is that of getting the spores away from the surface where they were formed, across the boundary layer of still, or non-turbulent flowing air at the solid-air interface, into the general circulation of the atmosphere. The thickness of this boundary layer varies with conditions, becoming thinner as wind speed increases, and thicker if the surface itself is rough. It will be thicker on the ground, thinner on a leaf or stem projecting into the wind. Pollen workers regard the lower 25–50 cm. near the ground as a region of mainly falling pollen, and for most purposes we may think of the boundary layer on a leaf or stem as of the order of a millimetre thick. Most Ascomycetes violently discharge their spores across this layer, and cup fungi by 'puffing' may achieve a ceiling of several inches. Many Basidiomycetes and flowering plants raise the reproductive structures into the air, and then drop the spores into the freely moving turbulent air-layer below. Once out of the calm layer of air close to the earth's surface the spores can be readily transported by wind.

The requirements of dry-air dispersal can be met by spores of a great range of size, varying from the large conidia of *Helminthosporium*, and the giant ascospores of the Pertusariaceae among the lichens, down to the minute basidiospores of puff-balls and earth-stars. They may be wettable or non-wettable, they usually travel singly but, as our trap records show, many smuts, *Cladosporium herbarum*, and *Penicillium* often travel in groups.

The elongated conidiophores of many Hyphomycetes, such as *Botrytis cinerea*, raise the spore head through the laminar boundary layer, and so do the apothecial stalks of such lichens as *Calicium* which have passively dispersed, powdery ascospores. Uredospores of rusts are often produced in flush pustules, but the still air layer on a leaf is normally thin, and the leaf itself is commonly raised above the ground. A remarkable adaptation is observed in some Entomophthoraceae where the infected insect climbs a plant shortly before dying at the end of a twig where sporulation of the fungus begins.

Once in the turbulent wind, above the still and laminar layers close to the surface, the movement of the spore is determined by several physical factors. Molecular forces, electrostatic effects and radiation can be neglected at this stage, and the main effects are wind, viscosity of the air, and gravity. Sinking of spores under gravity presumably has some effect on the total distance of dispersal, but our methods seem to be too crude to detect it at present, and we may ignore its effects so long as the spore is in the turbulent layer supported by the relatively viscous air. While a spore cloud travels downwind, turbulence will diffuse it sideways and upwards; and if the cloud has been liberated at a height above ground-level turbulence will diffuse it downwards faster than the effect of gravity. In the wind-tunnel, gravity effects are negligible at wind speeds above 1 m./sec. and the studies of Stakman, Henry, Curran and Christopher (1923), Dillon Weston (1929), Kelly, Pady and Polunin (1951), and others who have trapped spores from aircraft, show that effects of turbulence and convection are adequate to carry even large spores such as the uredospores of rusts to great heights in the atmosphere.

Considering the spore cloud, rather than the individual spore, we find that in dull windy weather, so common in Britain, it is possible to predict the rate of dilution of the spore cloud as it travels with the wind. As a first approximation the concentration depends on the distance travelled, and not on the time taken to travel the distance. The concentration after a given distance of travel is therefore more or less independent of wind speed. We may picture a single puff of spores, emitted from a point at a given instant. The cloud has a centre which is the mean position of the spores, and the individual spores are distributed about this centre with a standard deviation which is continually increasing as the cloud is diluted during travel by eddies of spore-free air. Sutton (1947) has shown for smoke and gases how this standard deviation can be calculated under various conditions of turbulence. I adapted Suttons's equations (Gregory, 1945) and found that for spores it was necessary to take into account another factor besides eddy diffusion, the loss of particles from the cloud by deposition on surfaces over which the cloud flows. With the limited data available from the literature agreement between theory and observed concentration as measured by spore traps, or by lesions on plants, was reasonably good.

It might be expected that once in the air, dry spores would mostly be carried far from their source, but under ordinary conditions this proves not to be so, and the bearing of this fact on plant pathology, fungus ecology, population genetics, and allergy is profound. Observations and theory agree that for spores or pollen liberated near the ground under normal conditions of turbulence, 99·9% of the spores will be deposited within 100 m. of the source. This is not to say that a very small proportion will not travel vast distances, but it is clear that most spores do not. This fact emerges from the data of Stepanov (1935), who liberated spores of *Tilletia caries* and *Bovista plumbea* in a meadow near Leningrad. It agrees with the work of Parker-Rhodes (1951) on the Basidiomycetes of Skokholm Island. It has been confirmed by Bateman (1947) in studies of pollen dispersion in connexion with vegetable-seed production. Bateman (1950) has pointed out that genes are not dispersed in a normal frequency distribution around their source, but show an excess above expectation both near the source and at extreme distances, while showing a deficiency at intermediate distances.

When spores are liberated under relatively calm conditions on clear nights, Sutton's equations indicate a still more limited range; perhaps only five spores in a million travel further than 100 m. This is of special importance in plant pathology where many of the phenomena we are concerned with happen at night rather than during our normal working hours.

Appreciable spore deposits from distant sources are to be expected only when the source of infection is not a single plant but a very large area. A somewhat dubious extrapolation indicates that under suitable conditions rust on early cereal crops in the States of Oklahoma, Arkansas, Missouri and Kansas could be sufficient to deposit several uredospores per square inch on a slide exposed at Winnipeg.

When turbulence is at a maximum, as on a hot summer afternoon, we have fewer data. Recent meteorological work suggests that under such conditions buoyancy effects may predominate. Bubbles of heated air may rise intermittently from areas of vegetation where the ground layer is being heated by the sun. These bubbles may rise more or less vertically to considerable heights, carrying their spore load to the level at which cumulus clouds are formed. Meanwhile, cooler air is drawn horizontally to replace the bubble, and presumably ordinary eddy-diffusion processes continue until the next bubble forms and ascends. Buoyancy probably forms an additional mechanism by which plant spores can be carried upwards, supplementing the normal upward diffusion due to the turbulence created by friction where wind flows over rough ground. We may guess that in hot cloudless conditions buoyancy predominates, and deposition near the source is then reduced, while transport to greater distances is increased.

The result of all these processes is that the air sometimes contains a very large number of spores. In local pollen clouds visible to the eye, Durham (1947) has recorded concentrations of from two million to nearly ten million pollen grains per cubic metre of air. At Rothamsted daily averages of conidia of *Erysiphe graminis* and *Alternaria* may reach thousands per cubic metre, and concentrations of *Erysiphe graminis* averaging 100 per cubic metre may persist for several weeks during early summer.

During air-transport the spore is liable to extreme desiccation and intense irradiation. Distant infection by sporangia of downy mildews and the basidiospores of rusts may be restricted by the death of spores. Many other spores are more resistant, the uredospores of rusts seem particularly well adapted to travelling long distances by air.

Deposition

Having become airborne and been transported hither and thither by the wind the next hazard facing the spore is that of getting down again and landing in the right place.

We have seen how the problem of take-off from the surface layer has been solved by different fungi in different ways which are reflected in certain characters of the spores. The problem of deposition has also been solved in different ways, and I suggest that some spore characters are adaptations for deposition.

I would like to keep the word 'deposition' for general use, not defining it too exactly, for any method by which a spore comes to rest on a surface. Little if anything was known about deposition processes until the development of wind-tunnel technique, originally for research in aerodynamics, had made it possible to experiment on the behaviour of spores in controlled winds in the laboratory. The principal methods of spore deposition can now be tentatively suggested: impaction, sedimentation, boundary-layer exchange, turbulent deposition, and rain-washing. Later on we may have to add to this list electrostatic deposition, but we do not yet know if it is a significant factor under natural conditions.

Impaction. When a small surface like a leaf or twig projects into the wind, spores may be deposited by impaction on the windward side. The oncoming air stream has to flow round the obstruction but airborne spores will be carried some distance towards it by their own momentum before they are in turn deflected by the laterally deflected wind flowing round the obstacle. If all those particles were impacted whose trajectories in the free wind stream would have passed through the obstruction, we should say that the impaction efficiency was 100 %, but apparently in practice it never is. Wind-tunnel experiments carried out at Rothamsted (Gregory, 1950, 1951) confirm that impaction is inefficient when small spores approach large obstructions at low wind speeds. Conversely, impaction is more efficient when large spores are blown towards small objects at high wind speeds. So it seems that large spores, in addition to carrying a bigger food reserve, have the advantage of being a favourable size for impaction on surfaces. Dry-spored, airborne leaf pathogens usually have comparatively large spores (uredospores, aecidiospores, *Phytophthora*, *Helminthosporium*, etc.).

On the other hand, dry-spored soil inhabitants are characterized by small spores, unsuitable for impaction (*Penicillium*, *Aspergillus*). Among vegetation where the wind speed normally reaches an upper limit of about 4 m.p.h., spores of *Lycoperdon perlatum* 4–5 μ diameter would not be impacted at all even on objects as narrow as 1 mm., and it can be calculated that spores of this size would require a wind of about 50 m.p.h. to be deposited with only 10% efficiency on a blade of grass. Evidently we must look to processes other than impaction to bring about the deposition of minute spores such as those of puff-balls, and earth-stars, *Ustilago*, and the common moulds. The loose smuts of cereals, *Ustilago* spp. with spores in the 8–9 μ range, would not be impacted efficiently on leaves and stems, but on narrow surfaces such as the glumes and stigmas of grass, they would be expected to reach an efficiency as high as 50–75 %. *Psalliota campestris* has spores 7 × 6 μ which should be near the lower limit for impaction on grass leaves, and above zero on grass stems at our selected wind speed of 4 m.p.h. Uredospores of *Puccinia graminis* and conidia of *Erysiphe graminis* would impact on a wheat leaf with efficiencies near 40–60 %. *Botrytis polyblastis* on a narcissus leaf, with spores up to 90 μ diameter, comes into the same group of pathogens relatively efficiently impacted on leaves and stems. The difficult problem of impaction on objects as wide as the trunk of a tree seems to have been solved by some of the lichens. *Pertusaria pertusa*, as I have found recently, can shoot single ascospores measuring 150 × 50 μ to a record horizontal distance of 40 mm. Extrapolation from wind-tunnel data suggests that once launched into a wind of only 4 m.p.h. these giant spores, nearly the largest in the fungi, would impact on a tree trunk 8 in. diameter with about 50 % efficiency.

While a high impaction efficiency may be necessary to fungi attacking leaves and stems, it may be disadvantageous for spores produced among dense vegetation. Johnstone, Winsche and Smith (1949) point out that the ability of a particle to penetrate among close vegetation is the inverse of its impaction efficiency. In close vegetation a high impaction efficiency would reduce the chance of a spore getting very far from its point of liberation. It is possible that the 10 μ diameter spore, perhaps the commonest range among dry airborne fungi (e.g. many ascospores and basidiospores), represents a workable compromise between the conflicting requirements of dispersal and deposition, evolved under the normal range of winds encountered among vegetation. The large-spored leaf- and stem-pathogens would appear as specialized *impactors*, while the minute-spored puff-balls and moulds would appear as specialized *penetrators*, perhaps normally deposited by processes other than impaction.

Sedimentation. Still air, as Tyndall (1881) found long ago, soon becomes freed of spores by settling under gravity, a process which we will call sedimentation. Out of doors, the air is almost never still except within about a millimetre of the surface. In the free, turbulent air layer above the ground the effects of gravity are slight and difficult to demonstrate, but Rempe (1937) has shown gravitational effects with tree pollens near Göttingen. Under turbulent conditions by day pollen grains of all sizes were usually equally abundant at all heights up to several thousand feet. On still nights, however, the larger grains sank more rapidly, and within a single species differences could be detected at different heights. On one night *Betula* pollen at 3000 ft. averaged 23 μ diameter, contrasted with 27 μ diameter near the ground. Under stable conditions on clear nights when air at ground-level is cooled by radiation, the laminar layer may extend to a height of several metres. This zone may be nearly cleared of pollen by sedimentation, while above it a much larger spore concentration may be retained in the turbulent layer.

Sedimentation, we therefore suppose, is only noticeable in the laminar layer which normally extends a few millimetres above the surface and under exceptional conditions at night may reach several metres. Wind-tunnel experiments confirm that the effect of sedimentation is slight at winds of 2 m./sec. and upwards.

Boundary-layer exchange is a process which we may imagine from time to time replenishes the laminar layer, and thus allows even minute spores to sediment. The demarcation between the laminar surface layer and the turbulent wind-stream is not constant. From time to time spore-bearing eddies break into the laminar layer, remove spore-free air, and leave in exchange small volumes of air laden with spores. These spores one imagines sediment under gravity, and presently fall out of the reach of further eddies. Turbulence is probably far more efficient in bringing spores down to a layer where they can sediment than is gravity acting on spores in the turbulent layer itself.

Turbulent deposition, I believe, has been observed only in the wind tunnel and on artificial spore traps in the open air. Spore-laden air flowing over horizontal surfaces will deposit spores at rates much greater than calculated for sedimentation under gravity. In the wind-tunnel turbulent deposition increases with wind speed, and at 10–20 m.p.h. deposition may be as great on the under side of a horizontal surface as it is on the upper side, an effect which clearly cannot be due either to impaction or to sedimentation under gravity. The effect has been noted on pollen traps by Durham (1944), and at Rothamsted.

The combined effect of all the deposition processes discussed so far results in a fairly rapid removal of spores from the air. Under English conditions we do not experience a long-continued build-up of atmospheric spore concentration in dry weather. My impression is that a day's spore output is more or less balanced by a day's deposition, at any rate for the larger spores, a conclusion in agreement with meteorological data on smoke pollution (Meetham, 1950).

Rain-washing, if it occurs, rapidly ends spore dispersal, and appears effective with small spores which are deposited only inefficiently by other processes.

Natural raindrops vary in size up to a maximum diameter of about 5–6 mm., above which they become unstable and break up into smaller droplets during fall. They have terminal velocities of fall varying from 2 to 9 m./sec. (Best, 1950). The pick-up of small spheres in the path of falling raindrops has been studied theoretically by Langmuir (1948) in connexion with artificial rain-making in Hawaii. To judge from Langmuir's data, the minute spores of *Lycoperdon* and the soil-inhabiting Penicillia would fail to be collected at all by drops much below 1 mm. diameter, and collection would rise to a maximum efficiency of about 15 % with droplets about 2 mm. diameter, decreasing again with still larger drops. Basidiospores of *Psalliota campestris* should begin to be collected by raindrops over 0·2 mm. diameter, reach a maximum of 30 % efficiency with 2·0 mm. and decrease slightly with larger diameters. Collection of *Tilletia caries*, of *Puccinia* uredospores, and of conidia of *Erysiphe graminis* would be above zero with any possible raindrop, reaching a maximum of about 80 % efficiency with drops 2·8 mm. diameter.

In our routine field trapping at Rothamsted we have collected rain-water and counted the number of spores of *Ustilago* (? *perennans*) brought down by raindrops. On 22 June 1951 we found, in round figures, that 2 mm. of rain falling during two hours brought down 200 times as many spores as were deposited during the whole day on a similar area exposed to wind but screened from rain.

The optimum size of spore for rain-wash deposition varies with the size of the prevalent drop. As we have seen, spores of *Lycoperdon perlatum* would fail to be collected by drops less than 1 mm. diameter, but I have shown that drops of less than this diameter do not operate the bellows mechanism of this species (Gregory, 1949). According to Langmuir's data, collection efficiency is at a maximum with drops of about 2 mm. diameter for all spore sizes, and is then about 25 % for 4 μ spheres, and 80–90 % for spores 20–30 μ diameter.

We know nothing of the pick-up of non-spherical spores. Of how properties other than size or terminal velocity affect collection by raindrops we also know little. Wettability obviously requires study. The spores of *Ustilago perennans* are not easily wetted by water, but are evidently easily collected by rain. The work of Burges (1950) suggests that when they reach the ground, like many other non-wettable spores, they remain in the upper layers of the soil. For leaf and stem parasites removal from air by rain probably means their end, while for small-spored soil inhabitants, smuts and other fungi infecting seedlings it is possibly the normal mode of going to earth.

AFTER DEPOSITION

Once deposited on a plant surface a spore is sunk too deep in the still boundary layer to be picked up again by ordinary winds. In the wind-tunnel we find that spores of *Lycopodium* begin to blow off potato leaves at winds above about 10 m.p.h. Under ordinary conditions a spore is probably safe from wind action after deposition, but until it has germinated it remains liable to be washed off by rain.

Passive dispersal and deposition of spores by the elements is a chancy business. Some few spores will alight on a susceptible host leaf or uncolonized dead tissue under conditions favourable for germination and growth. A new mycelium can then develop unhindered, but many spores will fall on barren ground. Here many species show evidence of a too-little-recognized plasticity. Our essential fungus, the nucleated mass of protoplasm which has migrated from the assimilative mycelial tubes into the spore, and after many vicissitudes has been deposited on an uncolonizable but moist surface, may immediately produce a hypha, migrate to the tip, and form another spore. This process is common in the Entomophthorales, is recorded in *Phytophthora infestans*, occurs as an unnamed conidial stage produced on germination of the ascospores of *Ophiobolus graminis*, is recorded of conidia of the Erysiphaceae, may possibly occur in the dermatophytes (Davidson & Gregory, 1934) and is well known in the Sporobolomycetes, in the Tremellales, and some rusts and smuts.

The wastage of spores is nevertheless enormous. The world is more or less fully populated with most fungi, and a fresh substratum will rapidly select its normal flora from the ample supply of suitable spores brought to it. In plant pathology we study a system temporarily unbalanced as the result of human activities—large, more or less pure stands of susceptible, artificial crop-plants which are renewed at regular intervals, are subject to attack by poorly adapted parasites. Dispersal gradients become obvious under these conditions, and isolation and quarantine methods can play a major role in limiting the development of a fungus flora on a crop. Willis (1940) claims that 'nothing in the distribution of plants would lead anyone to suppose that the "mechanisms for dispersal" have produced for the plants that possess them any wider dispersal than usual'. In the unbalanced condition necessary to agriculture this claim obviously fails, it is comparatively easy to limit the dispersal of *Synchytrium endobioticum* with its poor dispersal mechanism, but difficult with *Phytophthora infestans*, and impossible with *Puccinia triticina*, whose dispersal mechanism is excellent. Willis's claim refers to floras which man has not greatly disturbed.

So far as well established fungi are concerned Willis's criticism appears ustified. The immense output of spores probably does little to promote the extension of the range. When some accidental or cyclic effect offers a suitable environment within the range it rapidly becomes colonized and the average number of mycelia of the species is maintained. From this we need not necessarily deduce, as has usually been done hitherto, that all the rest of the spores are functionless. The higher fungi possess one characteristic unmatched in other organisms, their ability to form vegetative hyphal fusions mixing cytoplasm and nuclei from spores of different origin, and it is tempting to speculate as Transeau (1949) has done with *Coprinus variegatus*, that far more spores germinate and fuse with an already-established mycelium, than ever themselves succeed in establishing a new mycelium.

The work of Hansen and Smith (1932), on heterocaryosis, has shown that wild mycelia may contain genetically different nuclei. Some of these may be due to mutations in mycelia derived from a single nucleus, but experimental evidence shows that heterocaryons can also be produced by artificial mixing of suitable, genetically different mycelia, and it seems highly probable that this mixing process also occurs in nature. The value to a species of storing an adequate supply of mutant genes to be drawn upon in future and giving plasticity under varying conditions has been stressed by workers on fungus genetics: Craigie (1942), Whitehouse (1949).

Our speculation would suggest that among the higher fungi spore dispersal has one other function besides those of increasing the range, and colonizing new substrata within the range—that of dispersing genes and transmitting novelties, arising from mutation and recombination, between one established mycelium and another. The shift of sexual reproduction from the sedentary spores of the Phycomycetes, which lack hyphal fusion, to the dispersal spore form in the Ascomycetes and Basidiomycetes, may be a phase in the evolution of this habit. On this hypothesis a perennial mycelium would be the locus of activity and multiplication of individual nuclei, some perhaps descended from the original spore-colonizer, others descended from outside immigrant sources. The mycelium would remain, nuclei would come and go. The established mycelium would resemble a city rather than an individual—Dick Whittington came to London, made his mark there but left no descendants; his cat probably did. Thus besides their function as colonizers spores may perhaps act as an unreliable air-mail service transmitting genes between established mycelia.

Dispersal spores of some fungi such as the Gasteromycetes are hard to germinate. If we reject as first choice the hypothesis that they are functionless, we must suppose that there exist special conditions under which germination occurs naturally. The experiments of Ferguson (1902), who discovered that mushroom spores would germinate readily when in contact with living hyphae of the same species, are suggestive in this connexion. Other examples are known where spores are stimulated to germinate by hyphae of the same species, for instance the spermatia of *Puccinia helianthi* (Craigie, 1933). Experiment may show that this phenomenon of gene interchange plays a bigger part than we have hitherto considered possible. If this speculation is justified the production and dissemination of novelty must form a major activity among the fungi.

The physical environment of living organisms is a universe in which energy is continually running down into low-grade heat radiation. Organisms trap a minute proportion of this energy, temporarily diverting it into the production of novel forms. In this process we can distinguish four main tendencies dominating the activities of the fungi, as of other living organisms:

(1) A tendency to preserve the individual unit. Durable non-living bodies show this tendency too, but only in a simple way, as by being hard or non-explosive.

(2) A tendency to incorporate material from the external environment, and to grow and multiply.

(3) A tendency to colonize new territory.

(4) A tendency to produce and preserve novelty.

In a changing world all these tendencies have survival value, especially novelty.

These tendencies are merely descriptive. In stating them we are classifying phenomena, not explaining them. But, just as a railway time-table helps us to understand the activity that goes on at a terminal station, I think the statement of these tendencies makes coherent some of the restless activity of living organisms, and helps us to understand the significance of this immense outpouring of fungus spores.

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AQUATIC PREDACIOUS FUNGI. II

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(With 2 Text-figures)

An account is given of a new species of an aquatic Hyphomycete, a predator of nematodes, which produces boat-shaped biseptate conidia. Also recorded and described for the first time from Britain are *Stylopage lepte* Drechsler and *Dactylella heptameres* Drechsler.

redacious fungi are known to occur in rotting plant debris and in soil in his country but little is known concerning their distribution in water or aterlogged soil. Four species of predacious Hyphomycetes from aquatic ituations have recently been recorded from Britain (Peach, 1950). In this aper a new species of *Dactylaria* is described and *Stylopage lepte* Drechsler or the first time from Britain. A non-predacious Hyphomycete, *Dactylella eptameres* Drechsler, is also placed on record. Many species of *Dactylella* re known parasites of nematodes both in this country and in the United tates of America.

Dactylaria scaphoides sp.nov.

Mycelium hyalinum, septatum, hyphis saepe ramosis 3–5 μ crassis, reticula ex laqueis 5–50 μ diam. extus composita, quoque laqueo plerumque ex hypha separatim evolvente. onidia in hyphis fertilibus, ramosis interdum, ad altitudinem 130–690 μ ferens; conidia yalina, ellipsoidea pauca curvata, 1–3, plerumque 2-septata, 26–83 μ longa, 12–17 μ rassa, 5–12 in capitis ferens.

Vermiculos nematodeos capiens consumensque, hab. in foliis putridis herbae aquaticae *ypha latifolia* L., in luti ex lacuna Wisley, Surrey, Anglia. September 1950.

Small pieces of plant debris, chiefly leaves and rhizomes of *Typha latifolia* . together with mud taken from Wisley Pool, Surrey, were placed on aize-meal agar plates in September 1950. Various soil fungi appeared uring the ensuing weeks, but early in December 1950, a predacious yphomycete trapping eelworms by networks became conspicuous. The ng period between inoculation and subsequent appearance of a predaious Hyphomycete is of interest. In the past I have found this period has een a short one of a few weeks only.

The fungus produced networks (Fig. 1 *a*, *b*), many of large size, reaching 50 μ wide, and their efficiency resulted in the capture and death of many elworms, 230–520 μ long, and belonging to various genera. An infection ulb was protruded from part of the network into the body of the nematode Fig. 1 *c*), and assimilative hyphae developed, which digested the contents f the animal. No conidia were seen until a long period of predacious ctivity had occurred.

Erect conidiophores were 130–690 μ long; and they bore a terminal roup of large conidia, the number of conidia being usually from five to welve, though occasionally larger groups were found.

Conidia (Fig. 1*d* and 2*a*) were slightly curved or straight, broadly fusiform, 1- to 3- (mostly 2) septate, 26–83 μ long, and 12–17 μ wide.

In subcultures, infected with eelworms, the fungus showed profuse growth. The conidiophores frequently branched, and sporulation was intense. Anastomoses between fallen conidia were common. On germination, a tube developed from a terminal cell of a conidium (Fig. 1*d*), and produced a new mycelium, but frequently an aerial conidiophore 50–160 μ long was formed (Fig. 1*e*), bearing small, non-septate conidia in groups of about six. These secondary conidia were 14–22 μ long, and 5–8·5 μ wide. Attempts have been made to transplant secondary conidia on to fresh agar plates but so far, owing to contaminations, it has not been possible to decide whether germination occurs with production of a normal vegetative mycelium.

The fungus grows fairly well in pure culture, producing conidia but, as is usual with predacious Hyphomycetes of this type, no networks. The only reticulate species of *Dactylaria* which it resembles is *D. polycephala* Drechsler (1937), but there are several important differences. In Drechsler's species, in eelworm culture, the conidiophores bear a single terminal conidium, producing groups of three to twelve conidia only in pure culture. The conidia were described as 35–46 μ long, 8·5–12·5 μ wide and mostly 4-septate.

Drechsler (1944) described the conidia of *D. psychrophila* as being the largest known in this genus, 46–71 μ long and 21–29 μ wide, but the maximum length for this species is well exceeded by the conidia of *D. scaphoides* which is considered to be an undescribed predacious species of *Dactylaria* Sacc. with large, mostly 2-septate conidia. The epithet *scaphoides* is given to it because of the boat-like shape of the conidia; both the slightly curved and the straight types of conidia resemble a boat seen from two different aspects.

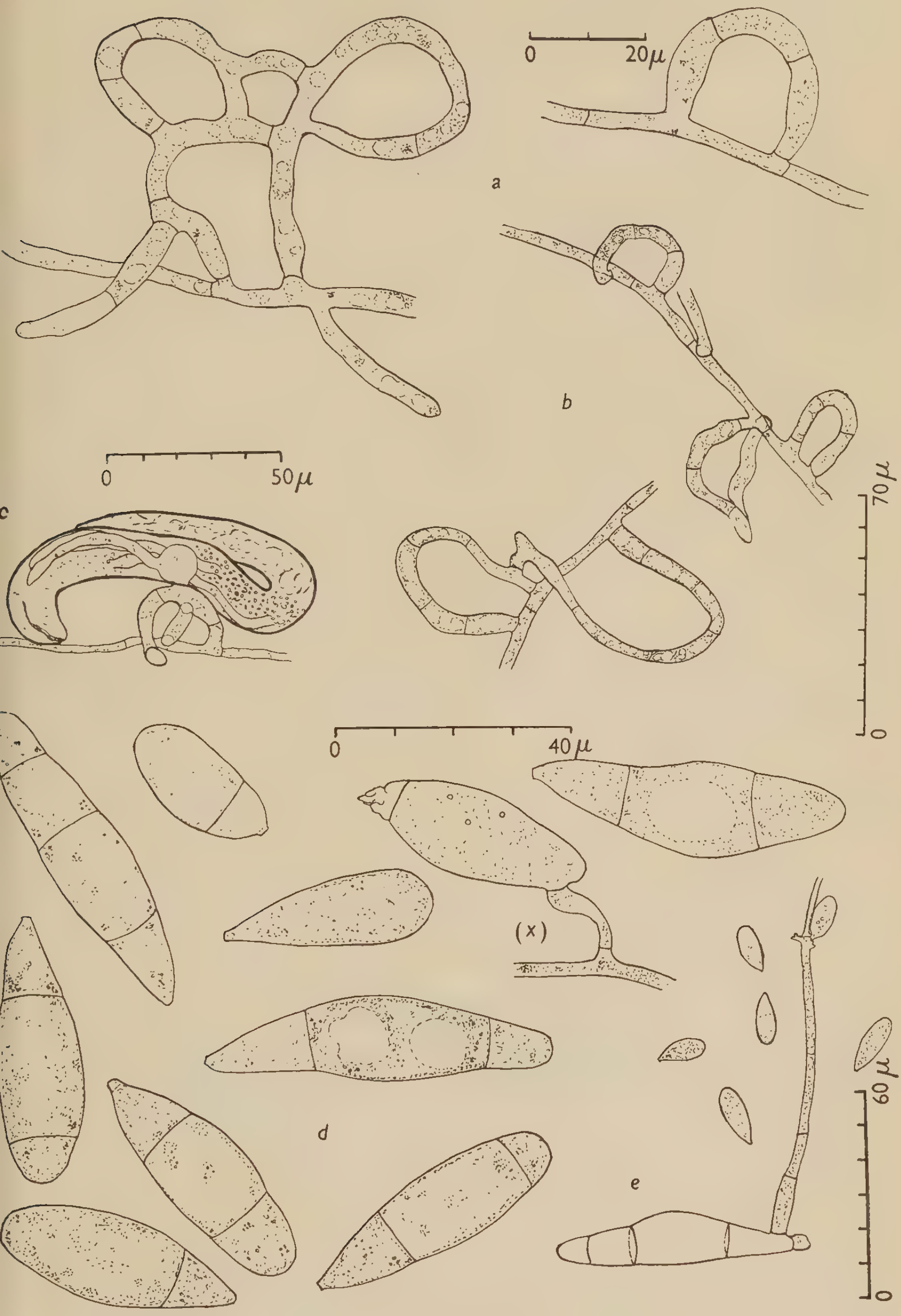
Type material has been deposited in the herbarium of the Royal Botanic Gardens, Kew, and in the herbarium of the Commonwealth Mycological Institute, Kew.

Stylopage lepte Drechsler

Samples of mud taken 4 feet from the edge and 1 foot down from the water surface of a pond near Horsham, Sussex, were placed on maize-meal agar plates. Within 3 weeks, a predacious Phycomycete was observed. The mycelium was delicate. Small amoebae measuring about 10 μ were trapped and haustoria (Fig. 2*b*), which branched dichotomously once or twice, protruded into their protoplasm. In the vicinity of the inoculum conidia were produced in large numbers.

Each conidium was borne singly on an aerial hypha (Fig. 2*c*), or more commonly conidia were produced in alternate succession on an erect conidiophore, the number of conidia produced on a single conidiophore being six, although occasionally seven to nine were found. Each conidium (Fig. 2*d*) was non-septate and oblong with tapering ends, the proximal being sharply tapered, 10–17 μ long and 2–2·8 μ wide.

Sexual reproduction was observed; the conjugating hyphae produced a spherical zygospore about 5 μ in diameter (Fig. 2*e*). The size and shape



ig. 1. *Dactylaria scaphoides*. *a* and *b*, networks; *c*, captured eelworm with infection bulb and assimilative hyphae; *d*, conidia, one of which (*x*) has germinated to form a new mycelium; *e*, germinated conidium with secondary conidiophore which has produced secondary non-septate conidia.

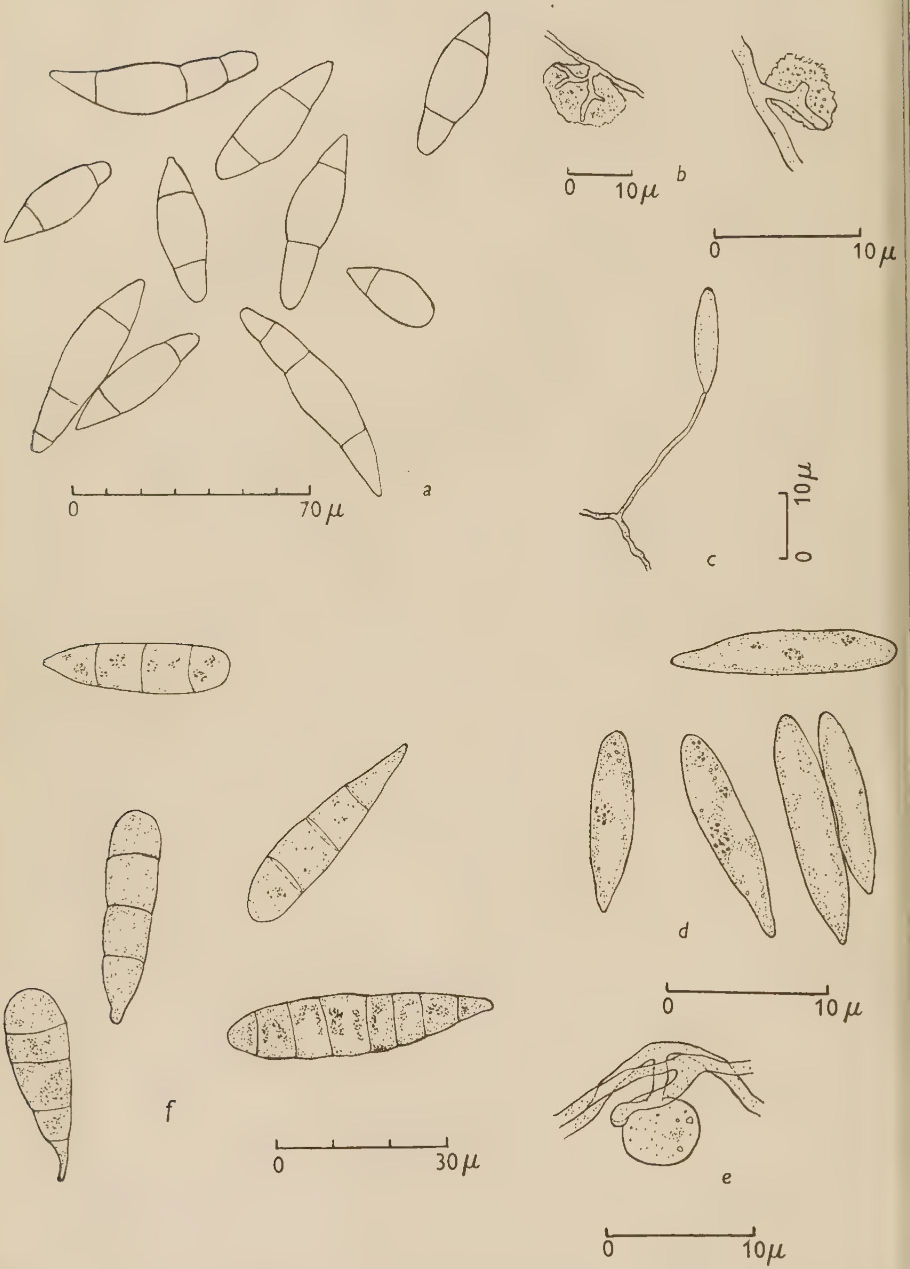


Fig. 2. (*a*) *Dactylaria scaphoides*, conidia showing range of shape; (*b*) *Stylopage lepte*, haustoria; (*c*) *S. lepte*, conidium on fertile hypha; (*d*) *S. lepte*, conidia; (*e*) *S. lepte*, conjugating hyphae and young zygospore; (*f*) *Dactylella heptameres*, conidia.

of the conidia, and their commonly occurring alternate arrangement indicate that this fungus is *Stylopage lepte* Drechsler (1935). One difference from his description of the fungus is the not uncommon occurrence of more than six conidia on a single conidiophore.

Dactylella heptameres Drechsler

Decaying leaf material taken 2½ feet from the edge of a pond near Effingham, Surrey, was placed in a sterile Petri dish containing distilled water. In a few weeks, conidiophores, each bearing a single septate conidium, were observed growing up from the inoculum. Small portions of the material were placed on maize-meal agar, and the same fungus was observed growing out on to the agar. No trace of predacious activity was observed although nematodes were present.

Pure cultures of maize-meal agar were easily obtained by the removal of conidia, and were normally faint pink in colour. Often, especially in pure culture, branching of the conidiophore occurred. Normal conidia were not produced when the room temperature was between 21 and 27° C. Eelworms were introduced into pure cultures of the fungus but no sign of predacious activity was ever observed.

Conidia were 3- to 7-septate, 32–53 μ long and 8–11 μ wide (Fig. 2*f*).

This fungus is clearly *D. heptameres* Drechsler (1943) which was described as non-predacious by the author.

Except where otherwise stated all measurements and illustrations in this paper were made from water mounts of fresh material growing on 2% maize-meal agar; and figures were drawn with the aid of a camera lucida.

I wish to thank Dr B. Barnes for his interest and guidance during the course of this work.

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TWO TECHNIQUES FOR SHOWING SPORE MARKINGS IN OPERCULATE DISCOMYCETES

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Descriptions are given of two procedures for staining callose-pectic spore markings with cotton-blue dyes. A technique employing lactic acid is recommended for temporary mounts, while a method using an aqueous dye solution has been devised for permanent mounts.

The ascospores of many of the species of Operculate Discomycetes have characteristic markings. These ornamentations are particularly useful in species identification, and have been the subject of a lengthy and detailed investigation by Dr Marcelle Le Gal (1947). The spore markings of most of the species (excluding the Ascoboleae and the Sarcoscyphaceae) are composed of a callose-pectic material which may be clearly stained and delimited by either of the techniques outlined below.

THE LE GAL TECHNIQUE

Cotton-blue dye is in use by many mycologists as a routine, general stain for the fungi. I have found it to be disappointing, however, when used on material of either Operculate or Inoperculate Discomycetes: overstaining and masking of details is all too common. Nevertheless, as a specific dye for callose-pectic spore markings, cotton blue is ideal for fresh, preserved, or dried material which has been revived in dilute (10%) ammonia. Thin sections of the hymenium are placed in a drop of the dye solution on a slide, a coverslip is added, and the slide then *gently heated* over a small flame until the solution just begins to boil. Slight pressure on the coverslip serves to straighten out the sections or to produce a smear, if that is preferred. The spore ornamentations take up the dye readily and appear deep blue in colour, while the wall of the spore remains almost colourless, enabling one to interpret precisely the markings which otherwise may only appear as indistinct roughenings.

Dr Le Gal's original technique called for dissolving 0·05 g. of cotton blue 'C 4 B' in 30 g. of lactic acid, boiling to dissolve the dye, and filtering after 24 hours. The results obtainable are excellent. I have tried several other cotton-blue and aniline-blue dyes, and have had almost identical results with all of these. However, I am not convinced that boiling the lactic acid to dissolve the dye is advisable, as there is a tendency for small precipitates to form on standing. The same amount of dye allowed to dissolve in lactic acid at room temperature for a few days prior to filtering has given equally good results, but without the objectionable precipitates. Workers who prefer lacto-phenol as a mounting medium may substitute this for the lactic acid with almost as excellent results.

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Permanent mounts may be made from slides prepared by this method, ut they are usually discouraging as the material is soon vastly overstained nd fogging of the slides is common. Sealing of the lactic acid or lacto-henol mounts is easily effected by the technique of Dade and Waller 1949).

Other fungi with callose or callose-pectic spore markings should also espond to the Le Gal technique. For example, Prof. C. T. Rogerson, now t Kansas State College, has had excellent results (as yet unpublished) vith this method in delimiting the spore markings in species of the ypocreales, particularly in *Hypomyces*.

THE PERMANENT MOUNT TECHNIQUE

his technique was devised in my search for a method of preparing ermanent mounts, the one feature in which the Le Gal technique held ittle promise. Aqueous solutions of water-soluble cotton blue are used, ·05 g. of the dye in 30 ml. of distilled water. I have used Hopkins and illiams 'Revector' stains, Soluble Blue 705, 706, and 707, all with ood results (but Soluble Blue 710 proved disappointing). A drop of ydrochloric acid added to the dye solution seems to intensify the stain. esorcin blue, which is used as a microchemical test for callose, stains only lightly, even in a 1 % aqueous solution.

Sections of the hymenium are placed in a large drop of the dye solution n a slide, which is gently heated until the solution just begins to boil. The ection is washed in a drop of water and then transferred to another slide, n which is placed a small drop of fructose (laevulose) syrup (25 g. of ructose in 20 ml. of warm water), and a coverslip added. The slide may e examined at once. The syrup is allowed to evaporate slowly at room emperature from the edges of the coverslip until it becomes quite thick several days at least), when the preparation may be ringed with any uitable substance. The fructose syrup apparently does not crystallize even f the slides are placed in a drying oven at 55° C. to hasten the process.

This method gives as vivid a colouring as does the Le Gal technique, and he slides seem quite permanent and not subject to overstaining. For urely temporary mounts, however, I have found the more rapid Le Gal echnique preferable. Both methods are unfortunately likely to produce ome plasmolysis and distortion of the spores and tissues.

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A NEW RUST ON *ANTIDESMA* IN INDIA

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(With 5 Text-figures)

A new rust, *Cystopsora antidesmatis*, was prevalent on leaves of *Antidesma diandrum* Roth. and *A. menasu* Miq. in South Kanara, India. This rust exhibits affinities with the two genera *Hemileia* and *Cystopsora*.

Cystopsora antidesmatis sp.nov.

Pycnia atque aecia ignota. Uredia hypophylla, minuta, superstomatalia, pulverulenta, luteo-aurantiaca; cellulae sporogenae dilatatae, plurima sterigmata ferentes; uredosporae ovatae vel globosae, fortiter echinulatae, parvo spatio ad basim excepto; parietes hyalini; contenta luteo-aurantiaca; $23 \times 20\mu$ ($19–28 \times 16–25$).

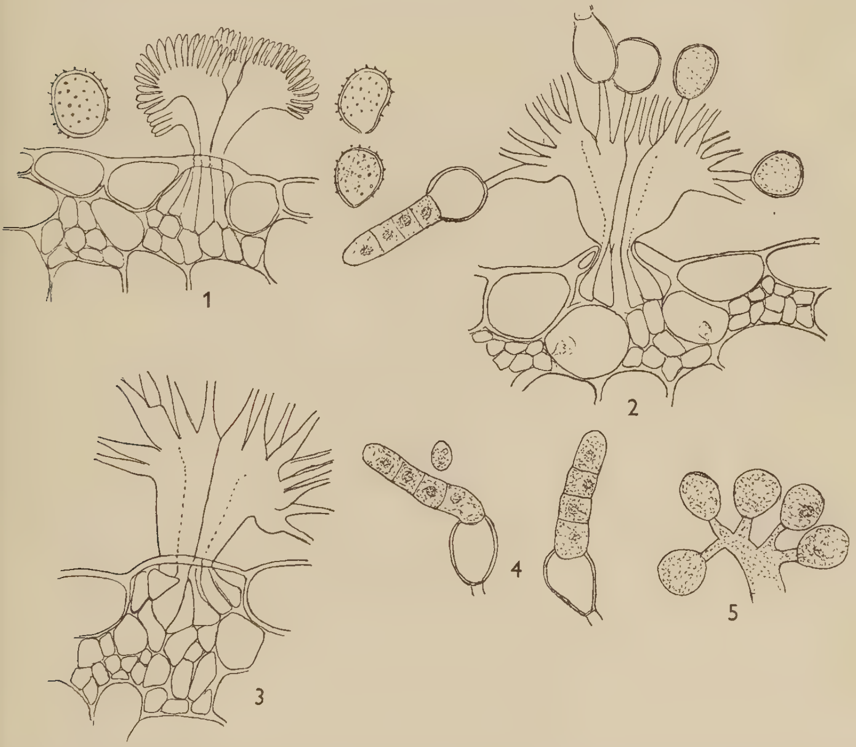
Telia hypophylla, minuta, alba, superstomatalia, cellulis basicis late clavatis, lateraliter unitis, plurimos pedunculos ad apicem ferentibus; teliosporae globosae vel ovatae, parietibus tenuibus, leves, 1-cellulatae, pedicellatae, hyalinae, $22 \times 19\mu$ ($19–28 \times 16–22$), maturae germinantes in situ, producentes basidia terminalia 4-cellulata atque valida; basidiosporae subglobosae, apparenter sessiles.

In foliis vivis *Antidesmatis diandri* Roth. atque *A. menasu* Miq., typus lectus in *A. diandri* in urbe Mangalore, in regione South Kanara, die 28 januarii 1951, a.cl. N.V. Sundaram.

An interesting rust is prevalent on the leaves of *Antidesma diandrum* and *A. menasu* in the Madras State. In the uredial stage it has a close resemblance to *Hemileia* while the telial stage exhibits affinity to *Cystopsora*. Raciborski (1900) described *Uredo antidesmae* on *Antidesma bunius* from Buitenzorg, Java. Later Sydow and Sydow (1914) named this *Hemileia antidesmae* Syd. The uredial stage alone was observed and the new name was based on this. No telium has been recorded. The uredial stage of the rust under study is apparently the same as that described for *H. antidesmae*. It has not been possible to compare the specimens with the type material, but the descriptions given by Raciborski and the Sydows agree with those of this rust. The telial stage is also present for this rust. Microscopic characters of this stage are more akin to those of *Cystopsora* than to those of *Hemileia*.

The infected leaves exhibit on the upper surface numerous minute irregular yellowish spots. On the lower surface the uredia develop as a dusty, yellowish orange, powdery growth. The internal mycelium is intercellular in the spongy parenchyma, forming compact groups of cells in the airspaces. Oval or globose haustoria are sent into many of the host cells. The hyphae collect in the substomatal air space forming a compact mass. Arising from this and passing through the stomatal pore is a cluster of hyphae laterally united to form a strand (Fig. 1). On emergence these enlarge and bulge out, but still remain laterally united. Developed from the free portions of the swollen parts are numerous closely packed sterigmata. The whole mass assumes a hemispherical shape. The urediospores are oval to subglobose with yellowish orange contents and strongly echinulate all over, excepting a limited area at the base. The spores measure 23 × 20 μ (19–28 × 16–25). All these characters are in agreement with those of *H. antidesmae.*

Later in the season numerous hypophyllous white telia are formed (Figs. 2 and 3). Their development is similar to that of the uredia. A strand of laterally united hyphae emerges through the stomatal pore. The cells swell into club-shaped structures, but still remain laterally united. At the apex, each of these gives rise to varying numbers of stalks (branched or not) each bearing one subglobose, one-celled, hyaline teliospore measuring 22 × 19 μ (19–28 × 16–22). The swollen cells can be designated as basal cells which give rise to several stalk cells. Partition walls are rare between the basal cells and stalk cells.



Figs. 1–5. *Cystopsora antidesmatis* n.sp. Fig. 1, uredium and urediospores; Figs. 2 and 3, telia; Fig. 4, germinating teliospores; Fig. 5, a cluster of young teliospores. (Magnification: Figs. 1–4, approx. × 350; Fig. 5, approx. × 500.)

The teliospore is globoid, thin-walled, smooth and hyaline, and germinates as soon as it is mature (Fig. 4). Many spores germinate *in situ*, giving rise to a tangled whitish mass of basidia and sporidia. The germina-ion is by an apical, stout, 4-celled promycelium which is separated from he spore by a convex septum bulging into the spore, as has been observed n *Blastospora.* The basidiospores are round or oval, hyaline and apparently essile since the formation of sterigmata on the basidia has not been noticed.

As already stated, this rust shows resemblance to *Hemileia* and *Cystopsora*. In the development and general appearance of the uredia it resembles *Hemileia*, but the development of the sterigmata from the enlarged sporogenous cells is peculiar. Furthermore, the urediospores are not of the characteristic shape observed in *Hemileia* but are oval or spherical. The appearance of the telium and the spherical shape of the teliospore are quite different from what has been observed in *Hemileia*. The telial structure is more like that of *Cystopsora* with numerous pedicellate round teliospores (Fig. 5) from a cluster of laterally united enlarged generative or basal cells. A comparison with *C. oleae* Butler (1910) showed a similarity in the development of the telia, but the germination of the teliospore is unlike that recorded in *Cystopsora*. The basidium is not basally formed but more or less terminal. Further it is not semi-internal as in *Cystopsora* but more or less external with the base projecting into the spore and cut off by a convex septum.

This rust appears to occupy an intermediate position between *Hemileia* and *Cystopsora*. Pycnia and aecia, but not uredia, have been recorded for *C. oleae*, whereas this rust has well-developed *Hemileia*-like uredia, but no pycnia or aecia are known. Dietel (1923) considers the peculiar dorsiventral formation of urediospores and the angular teliospores to distinguish *Hemileia* from *Cystopsora*. In both these features the rust under study differs from *Hemileia*. From a consideration of all these factors it is considered advisable to place this rust in the genus *Cystopsora* though the germination of the spores is not typically semi-internal.

We are indebted to Dr G. R. Bisby for help and advice. We thank Rev. Fr. H. Santapau for rendering the diagnosis into Latin.

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THE TAXONOMY OF *OPHIOBOLUS GRAMINIS* SACC.

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(With 1 Text-figure)

The structure of perithecia, asci and spores in *Ophiobolus graminis* Sacc. indicate that the affinities of this fungus lie with the Diaporthaceae-Gnomoniaceae, while the typical species of the genus *Ophiobolus* are members of the Pseudosphaeriales. *O. graminis* is the type species of the new genus *Gaeumannomyces*. It is most closely related to *Linospora* Fuckel, *Ophiognomonia* Sacc. and *Plagiosphaera* Petrak.

The fungus which causes Take-all and Whiteheads of wheat and other cereals has been described as *Ophiobolus graminis* (Sacc.) Sacc.; but, as has already been recognized by several workers, it differs entirely from the type of the genus *Ophiobolus* Riess and so it must receive another generic name. Nannfeldt (1932) places '*Ophiobolus*' *graminis* in the Gnomoniaceae on the grounds of its method of spore-dispersal described by Jones (1926). Holm (1948) considers that the species should be placed in the neighbourhood of *Plagiosphaera* Petrak.

Ophiobolus acuminatus (Sow.) Duby = *O. disseminans* Riess must be considered the type species of the genus *Ophiobolus*. This fungus has globose fruiting bodies sunk in the substratum, communicating with the exterior by means of a short, cylindrical perithecial neck. Early in development this structure forms a pore, which is lined with short, periphysis-like hyphae. The asci are numerous, long and cylindrical, with a somewhat tough and apically slightly thickened double membrane, but no dehiscence mechanism. The filiform spores are nearly as long as the asci, measuring up to 150 μ, have numerous septa, and are of a yellow or olive-brown colour. When ripe they break in halves.

O. acuminatus is a member of the Pseudosphaeriaceae (Pleosporaceae). This fungus, like all species typical of the genus *Ophiobolus*, is closely related to the more highly evolved types of *Leptosphaeria;* for example, to *L. derasa* Rabenh. (see Müller and von Arx, 1950). The two genera differ only in their spore-structure; *Leptosphaeria* has phragmospores and *Ophiobolus* scolecospores. Transitional forms occur.

We have not seen the type specimen of *Ophiobolus graminis* but have found, by examining other collections, that the perithecial centrum is of the type characteristic of the Diaporthales, to which order the Gnomoniaceae belong.

O. graminis has the following structure. *Perithecia* single, immersed, more or less globose, often somewhat obliquely placed, but not horizontal, 300–500 μ, diam. *Perithecial necks* broadly cylindrical, usually inserted somewhat to one side but never bent at an angle of 90°, 160–250 μ long and about 180 μ broad, becoming somewhat narrower towards the apex and forming a papillate projection above the surface of the substratum.

Perithecial wall about 40–55 μ thick, consisting of several (usually six to seven) layers of moderately thick-walled, brown, slightly compressed but clearly defined (not filamentous) cells, 4–12 μ long. *Pore* 40–50 μ wide, and thickly lined with upwardly directed periphyses; the inner layer made up of small, indistinct cells; on the lower half of this layer the asci are produced. *Asci* with stalks of varying length, and accordingly at different levels; slender, cylindrical to club-shaped, apically truncate, tapering at the base into the soft-textured but comparatively thick stalks. Ascus wall thin, delicate, and exhibiting the highly refractive protoplasmic ring in the thickened tip which is characteristic of the Diaporthales. Asci measuring 70–110 × 10–15 μ without their stalks; and containing eight spores. *Spores* lying parallel and slightly spirally twisted in the asci; vermiculate, blunt-ended and hyaline, containing numerous oil-droplets when young; when ripe, with several, usually five pseudosepta; 65–95 × 3–4 μ. *Paraphyses* very numerous at first, filamentous and very delicate; containing oil-drops; evanescent.

The fungus is a scolecosporous member of the Diaporthales. However inconvenient it may be for phytopathologists, the fungus causing Take-all cannot remain in the Pseudosphaerialean genus *Ophiobolus*, but must be transferred to the Diaporthales, under a new name.

First, we must decide whether it may be assigned to any of the existing genera of this order. The following scolecosporous genera must be considered: *Linospora* Fuckel, *Ceuthocarpon* Karst., *Pleuroceras* Riess, *Ophiognomonia* Sacc. and *Plagiosphaera* Petrak. A short description of each of these genera follows.

Linospora Fuckel

In the type-species, *L. capreae* (DC.) Fuckel, the fruiting bodies are deeply sunken in the leaf tissue and surrounded by a pseudostroma which is limited by a dark clypeus on both upper and lower surfaces of the leaf. The perithecia communicate with the exterior by means of a long beak-like papilla which grows apparently from the side of the horizontal fruiting-body and bends sharply upwards at an angle of 90° (Fig. 1). All spores examined were non-septate (cf. Klebahn, 1918).

Ceuthocarpon Karst.

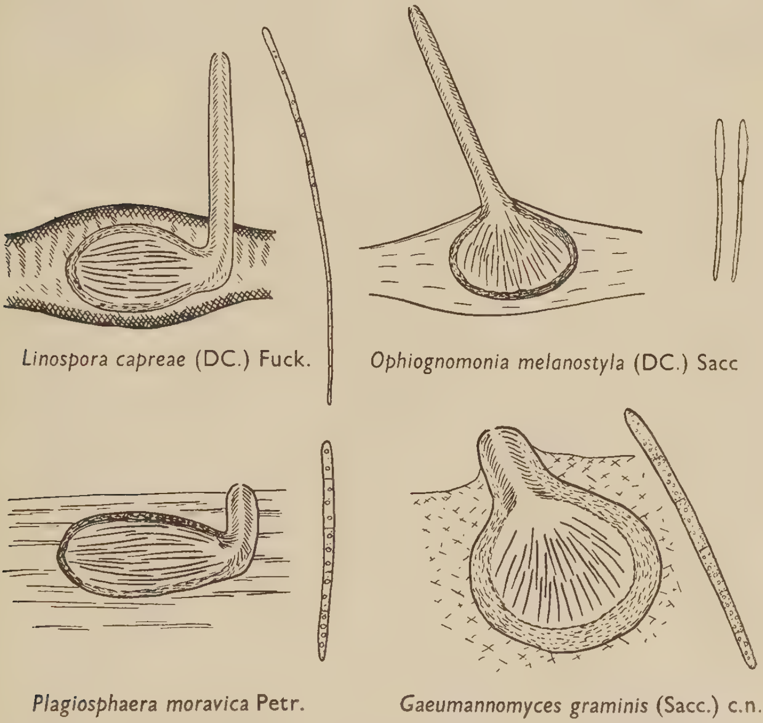
This genus was reduced to synonymy with *Linospora* Fuckel by Saccardo (1883) and Winter (1884–7) as the type species *Ceuthocarpon populinum* (Pers.) Karst. is in all important points identical with *L. capreae*.

Pleuroceras Riess (= *Cryptoderis* Auersw.)

The type species *P. cryptoderis* (Lév.) v. Höhnel (= *Cryptoderis lamprotheca* (Desm.) Auersw.) also has horizontally placed perithecia. The perithecial neck, once more produced apparently laterally, is much elongated. This fungus differs from the other genera described here chiefly in the structure of the spores, which, though scolecosporous, tend to be somewhat fusiform in shape, and are slightly constricted at the single, median cross-wall. Mature spores break in half at the cross-wall.

Ophiognomonia Sacc.

The type species is *O. melanostyla* (DC.) Sacc. (=*Pleuroceras melanostyla* DC.) v. Höhnel). It is parasitic on leaves of *Tilia*. The slightly flattened lobose perithecia have a long, thin neck, which is often inserted somewhat symmetrically. The spores are not typically filiform, but have an apical, omewhat clavate swelling, which is separated from the tail-like remainder f the spore by a cross-wall (Fig. 1). This may be seen while the spores are till in the asci.


Linospora capreae (DC.) Fuck.

Ophiognomonia melanostyla (DC.) Sacc

Plagiosphaera moravica Petr.

Gaeumannomyces graminis (Sacc.) c.n.

Fig. 1. Diagrammatic median sections of perithecia (magnification, 60 ×) and structure of the ascospores (500 ×)

Plagiosphaera Petrak

The type species *P. moravica* Petrak (syn. *Ophiobolus moravicus* Petrak) as, according to Petrak (1941), fairly deeply sunken horizontal perithecia. hey are considerably elongated in the plane of the substratum. The pparently lateral neck is bent upwards at an angle of 90° and is cylinrical. The perithecial wall is lighter in colour on its lower than on its pper side. The spores are non-septate at first and contain numerous oilrops; later they develop indistinct cross-walls as a result of divisions in e plasma.

If we compare the description of these genera with that of *O. graminis* e can see that this species cannot justifiably be placed in any of them.

The closest relationship is, as observed by Holm (1948), with *Plagiosphaera;* but our fungus differs from this genus in the globose perithecium and in the angle of the neck, also in its much thicker wall.

It must therefore be considered the type of a new genus, which we propose to name *Gaeumannomyces* in honour of Prof. E. Gäumann of Zürich.

Gaeumannomyces nov. gen.

Perithecia dispersa vel subaggregata, omnino immersa, globosa, nigra, collo cylindraceo subelongato, saepe obliquo, cum poro periphysibus punctiformiter pertuso, erumpente. Paries membranacea, pseudoparenchymatica, olivacea vel atro-brunnea. Asci numerosi, tenuiter tunicati, stipitati, 8 spori, apice annulo refractivo. Sporae in asco parallelae, filiformae, primo continuae, ad maturitatem indistincte septatae, hyalinae. Paraphyses filiformae, tenuissimae, mox mucosae.

Perithecia single, dispersed, sunken in the substratum, globose, black, communicating with the exterior by means of a periphysis-lined pore in a cylindrical, usually somewhat unilaterally inserted beak. Perithecial wall pseudoparenchymatous, light or dark brown. Asci numerous, cylindrical, thin-walled, stalked, with eight spores and a refractive ring in the slightly thickened apical wall. Spores parallel in the ascus, vermiculate, hyaline, continuous when young, with pseudosepta when ripe. Paraphyses filamentous and very delicate, evanescent.

The type species must be named *Gaeumannomyces graminis* (Sacc.) nov. comb. (syn. *Rhaphidophora graminis* Sacc., *Ophiobolus graminis* Sacc. (Saccardo, 1875, 1883). Without examining the original collection it is not possible to say whether *O. cariceti* (Berk. & Br.) Sacc. is identical with our species. It appears, from the account given by Fitzpatrick, Thomas and Kirby (1922) that the condition of the type is not satisfactory; we do not consider that these authors are justified, on the evidence they submit, in regarding the two species as unquestionably the same. We therefore consider it advisable to retain the specific epithet *graminis*.

As an important parasite of cereals, *Gaeumannomyces graminis* has been the subject of a considerable body of research. In this connexion, the work of Jones (1926) on the developmental morphology of the fungus is noteworthy; his paper also contains a number of good figures. Défago (1942) gives an accurate diagram of the asci. For information on the pathogenicity and dissemination of the parasite, the list of references given by Butler and Jones (1949) should be consulted.

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NEW OR RARE BRITISH HYMENOMYCETES (APHYLLOPHORALES)

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(With 37 Text-figures)

In this paper are described fifty-three species and one form, of which forty-four species and the form are new records for the British flora. The remaining species are included either because of their rarity or on account of some noteworthy feature. Two new species, *Aleurodiscus delicatus* and *Peniophora reticulata*, are described, the latter near to *P. argillacea* but considered sufficiently distinct to be worth a name. One new combination is made and two new names proposed.

During a rather long period, in which work on resupinate Hymenomycetes has been much interrupted by other duties, a number of records of species new to this country have accumulated. Some of these are my own collections; many more the result of forays by mycological friends. An attempt is made here to give descriptions of all those whose identity has been established, except for species of *Tomentella*, which are reserved for a separate paper. Some of the specimens were named at once and have been included in foray lists: others presented difficulties which have only recently been resolved. To all those who have assisted in the collection of material my grateful thanks are due. I wish also to express my gratitude to the Director of the Botanical Department, Riksmuseum, Stockholm, for allowing me to examine the type specimens of some of the species described by Bresadola.

Colour terms written with capital letters are from Ridgway's *Color Standards and Color Nomenclature* (1912).

Leptoporus kymatodes (Rostk.) Pilát in Kavina and Pilát, *Atlas des Champignons de l'Europe*, **3**, 214, 1936.

Polyporus kymatodes Rostk. in Sturm, *Dtsch. Flora*, **3**, 4 (t. 24), 1838.

Pileus horizontal, dimidiate, usually imbricate, prolonged behind into an effused portion which unites the superimposed pilei, variable in size, up to 10 cm. wide and 4 or 5 cm. from front to back, fleshy-tough when fresh but drying hard and rigid, the upper surface whitish to buff, more or less zoned with grey or brownish, margin whitish, adpressedly fibrillose or silky at first. *Flesh* usually rather thin, fleshy-tough, fibrous and obscurely zoned, rigid when dry, white, becoming more or less rose-tinted when fresh. *Tubes* white, soft and fleshy when fresh, 1–4 mm. long, forming a layer distinct from the flesh of the pileus. *Pores* angular, unequal, sometimes elongated, three to five to a mm., white or pale, often with a rose tint, especially when bruised, at first entire but finally somewhat drawn out into teeth. *Hyphae* 3–6 μ in diameter, very thick-walled, with clamp-connexions at the septa. *Basidia* 12–18 × 4·5–5·5 μ. *Cystidia* present in adult specimens, ovoid-spindle-shaped or bulbous, thin-walled, smooth, otuse or pointed above, 15–18 × 7–10 μ. *Spores* ovoid-elliptical, usually ith an oblique apiculus at the base, smooth, hyaline, usually with one l-drop, 3–4·5 × 1·5–3 μ.

Usually on trunks of conifers, rarely on deciduous trees.

Mickleham, Surrey, November 1927 (a very dark form, determined by e Abbé Bourdot); on larch, Donhead St Mary, Wilts, A. E. Dunston, ctober 1939 and August 1940; Epping Forest, October 1941; on elm ump near Maidstone, Kent, July–August 1945; on living yew, Norbury ark, Mickleham, N. Y. Sandwith, October 1945; on larch, Royal otanic Gardens, Kew, R. W. G. Dennis, October 1946; on Scots pine ear Midhurst, A. A. Pearson, November 1947; Haslemere, Surrey, A. A. earson, November, 1947.

This fungus was first recorded as British in *Wiltsh. archaeol. nat. Hist. Mag.* , 153, 1940. As shown by the specimens listed, it appears to be not ncommon in the southern counties, and it is strange that it was not ecognized until recent years. It was placed in the genus *Coriolus* by ourdot and Galzin, with a query as to whether it should be referred to *eptoporus*. It is an undoubted *Leptoporus*, with the pore-layer distinct om the flesh, and has been rightly transferred by Pilát.

eptoporus rufoflavus (Berk. & Curt.) Pilát in Kavina and Pilát, *Atlas des Champignons de l'Europe*, **3**, 220, 1936.

L. Braunii (Rabenh.) Pat., *Essai Taxon.* p. 85, 1900.

Pileus small, 2–3 cm. wide and 1 cm. or less from front to back, thin, avy, dimidiate, often imbricate, or thickened and produced behind; pper surface at first finely velvety but soon quite smooth, zoned, red-rown, the margin at first whitish or yellow. *Flesh* thin, pale yellowish en brown. *Tubes* pale yellow, sometimes stratified. *Pores* minute, seven ten to a mm., rounded, with rather thick dissepiments, bright yellow. *yphae* yellowish, closely adherent and not very distinct, 2–3 μ. *Cystidia* resent, hyaline, cylindrical or fusiform, obtuse or pointed, heavily crusted above with crystals, 18–30 × 7–8 μ, usually embedded in the ymenium. *Basidia* short, 5–6 × 2–3 μ. Spores small, hyaline, subglobose, × 1·5–2 μ.

On timber in a coal-mine, Northumberland, A. C. Dennis, November 46.

This little species is a native of tropical regions, occuring in both Old d New Worlds. In Europe it is found only in glasshouses and in mines, here temperature and moisture conditions are suitable. It is easily cognizable by the minute, bright yellow pores, contrasting with the red-own upper surface, and microscopically by the small subglobose spores d the large, encrusted cystidia, resembling those found in *Poria eupora*.

hellinus torulosus (Pers.) Bourd. & Galz. in *Bull. Soc. mycol. Fr.* **41**, 191, 1925.

Polyporus torulosus Pers., *Mycol. Eur.* **2**, 79, 1825.

Pileus rust-brown, sessile, dimidiate and applanate or effuso-reflexed d almost conchoid, 10 cm. or more broad, up to 3 cm. thick behind, e reflexed portion 3–5 cm. from front to back; upper surface tomentose, bright brown (Amber Brown to Argus Brown), concentrically grooved, becoming blackish behind with age, margin rounded, sterile below. *Flesh* bright rust brown (Amber Brown), corky or somewhat hard but compressible with the finger-nail, somewhat fibrous, obscurely zoned. *Tubes* indistinctly stratified, 3–10 mm. long, coloured like the flesh but paler. *Pore-surface* cinnamon to rust-brown, often with a greyish bloom, *pores* minute, rounded. *Hyphae* thick-walled, regular, pale brown, becoming darker when treated with KOH, 2–3 μ diam. *Setae* present in the hymenium, abundant, subulate, the apex sometimes curved, 20–40 × 5–7 (–12) μ, projecting up to 25 μ. *Spores* hyaline, elliptical or subglobose, usually 1-guttulate, 4–6 × 3–4·5 μ (measurements according to Pilát; spores not found in the present specimen).

On dead stump of *Arbutus unedo*, Muckross, Killarney, R. W. G. Dennis, August 1946.

This species is found in the warmer regions of Central Europe, in France, South Europe and North Africa, but has not previously been recorded from the British Isles. It is said to grow on both living and dead trunks of various deciduous trees and to cause a fairly active rot of the wood. It differs from *Phellinus ribis* in the thicker pileus with swollen margin, the hyaline spores and the presence of setae, from *P. conchatus* and *P. robustus* in the more rust-brown and compressible flesh and in the smaller and more elliptical spores.

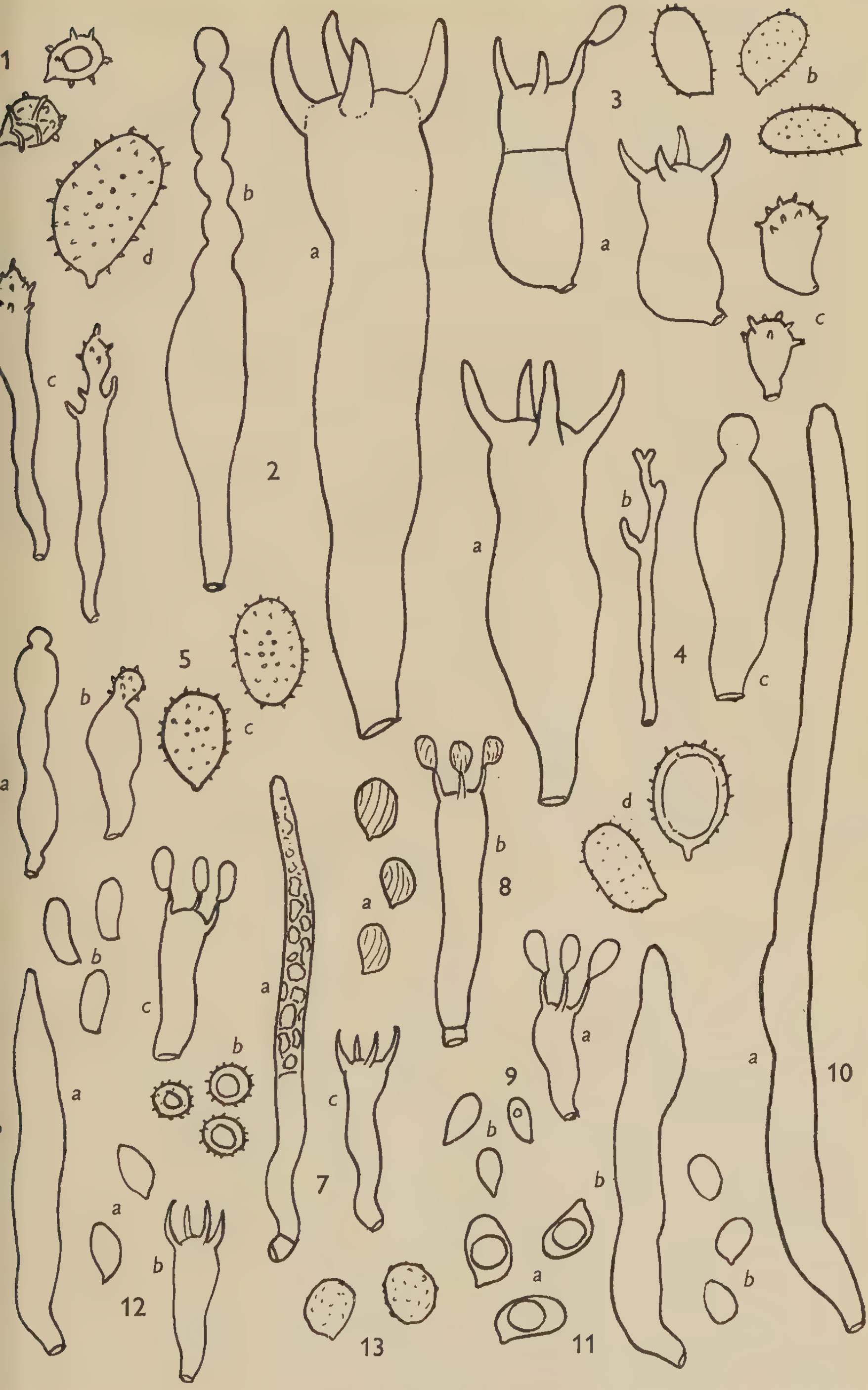
Phellinus robustus (Karst.) Bourd. & Galz. in *Bull. Soc. mycol. Fr.* **41**, 188, 1925, forma **Hippophaës** Lundell & Nannfeldt in Fungi Exsicc. Suec. No. 449.

This small form of *P. robustus*, which seems peculiar to the Sea Buckthorn (*Hippophaë rhamnoides*) was first described by Donk in a footnote to his description of *Ochroporus robustus* (Karst.) Donk, *Med. bot. Mus. Rijksuniv. Utrecht*, **9**, 248, 1933, without however being given a name. The name f. *Hippophaës* was used by Lundell and Nannfeldt in their Exsiccati and was included by Pilát in his account of the Polyporaceae already quoted.

The sporophores are rather small (3–7 cm. across), rounded, sessile, and often embracing the branch on which they grow. The habit strongly suggests *Phellinus pomaceus*, from which the present species differs in the brighter brown flesh and more yellowish pores, and in having few or no setae in the hymenium.

Legends to Figs. 1–13

Fig. 1. *Lindtneria trachyspora*, spores.
Fig. 2. *Aleurodiscus Oakesii*. *a*, basidium; *b*, pseudophysis; *c*, acanthophysis; *d*, spore.
Fig. 3. *A. delicatus*. *a*, two basidia; *b*, spores; *c*, acanthophyses.
Fig. 4. *A. aurantius*. *a*, basidium; *b*, forked paraphysis; *c*, pseudophysis; *d*, spores.
Fig. 5. *A. apricans*. *a*, pseudophysis; *b*, acanthophysis; *c*, spores.
Fig. 6. *Corticium* (*Gloeocystidium*) *pallidum*. *a*, gloeocystidium; *b*, spores; *c*, basidium.
Fig. 7. *C.* (*Gloeocystidium*) *granulosum*. *a*, gloeocystidium; *b*, spores; *c*, basidium.
Fig. 8. *C. pulverulentum*. *a*, spores; *b*, basidium.
Fig. 9. *C. asseriphilum*. *a*, basidium; *b*, spores.
Fig. 10. *C.* (*Gloeocystidium*) *geogenium*. *a*, gloeocystidium; *b*, spores.
Fig. 11. *C.* (*Gloeocystidium*) *lentum*. *a*, spores; *b*, gloeocystidium.
Fig. 12. *C. reconditum*. *a*, spores; *b*, basidium.
Fig. 13. *C.* (*Gloeocystidium*) *analogum*, spores.



Figs. 1–13. (All figures, × 800.)

On *Hippophaë rhamnoides*, Lincolnshire, Miss G. M. Waterhouse, November 1948.

Poria metamorphosa (Fuckel) Sacc., *Syll. Fung.* **6**, 315, 1888.

Polyporus metamorphosus Fuckel, *Symb. Myc.*, Nachtr. **2**, 87, 1873; as form of *Poria aneirina* (Sommerf.) Cooke in Bourd. & Galz., *Hym. Fr.* p. 668, 1928.

Effused, thin, cream to alutaceous, with large, shallow, irregular, angular pores, up to 0·75 mm. in diameter, sometimes becoming irpicoid. *Hyphae* hyaline, then becoming golden yellow, 3–5 μ in diameter. *Basidia* 20–25 × 4–6 μ, clavate, with two to four sterigmata. *Basidiospores* oblong or cylindrical, sometimes slightly curved, 5–7 × 2·5–3 μ. Along with the normal *Poria* there is a conidial form, bearing abundant, orange-coloured conidia which are broadly elliptical, 9–12 × 4–7 μ, usually containing one guttule.

On debris on the ground, Cotterill Clough, Cheshire, Miss B. Harthan, July 1946, and again October, 1949.

Cultural experiments conducted at the Forest Products Research Laboratory, Princes Risborough, showed that the conidia belong to the *Poria* form. It seems better at present to keep the species distinct than to assume that *P. metamorphosa* is necessarily a form of *P. aneirina*.

Lindtneria trachyspora (Bourd. & Galz.) Pilát in *Stud. Bot. Čech.* **1**, 72, 1938.

Poria trachyspora Bourd. & Galz. in *Bull. Soc. mycol. Fr.* **41**, 219, 1925.
Sistotrema sulphureum var. *retigera* Bourd. & Galz. in *Bull. Soc. mycol. Fr.* **30**, 274, 1914.

Effused, forming rounded patches from 1 to 3 cm. across. When fresh at first golden yellow, then becoming vinaceous red or purplish, soft, somewhat separable; when dry vinaceous, pulverulent, soft and cottony, with paler margin. *Hymenium* reticulately porose, pores shallow, angular, often incomplete, up to 1 mm. diam. The reddish colour of the hymenium dissolves in potash solution giving a rose colour. *Hyphae* 3 μ in diameter, without clamp-connexions, sometimes swollen at the septa up to 5–15 μ, occasionally forming strands. *Basidia* clavate or shortly cylindrical, up to 10 or 12 μ wide, with four short sterigmata about 5 μ long. *Spores* ovate, yellowish, aculeate and reticulate, with a basal apiculus, containing usually a single oil-drop, 8–9 × 6–7 μ (without spines or apiculus). (Fig. 1.)

On rotten wood in a swampy place, Ross Island, Killarney, A. A. Pearson, September 1936; Wicken Fen, Cambridge, E. J. H. Corner, August 1926; on bare peat, Wicken Fen, P. K. C. Austwick, October 1949.

This seems to be a rare fungus in Europe, having been recorded only very few times, though from widely separated localities in France, Jugoslavia, Tyrol and Spain. Judging from the collections in this country it appears to be a plant peculiar to very wet habitats. It is easily identified by its striking golden-yellow colour, turning to a vinaceous tint when old, or when dried, by the soft texture and large shallow pores, and by the large, curiously reticulate spores, the reticulation being due to bands of irregular thickening which show in optical section as spines on the outer surface.

Trechispora onusta Karst. in *Hedwigia*, **29**, 147, 1890.

Poria onusta (Karst.) Bres. in *Ann. mycol., Berl.*, **6**, 41, 1908.

Effused, very soft and fragile. *Subiculum* byssoid, golden yellow, paler towards the margin. *Hymenium* poroid; *pores* very shallow, large (0·5–1 mm. diam.), angular, thin-walled, deep orange-yellow. *Hyphae* with clamp-connexions, thin-walled, 3–3·5 μ. *Basidia* at first more or less ovoid, then elongated above and becoming urniform, 6·5–8 μ wide. *Spores* globose or subglobose, smooth, 4·5–5 μ diam. or 5 × 4 μ.

Amongst plant debris on the ground, Tilgate Forest, Sussex, J. Harvey Bloom, December 1928.

The species seems to be very rare, both here and on the Continent. It is recognizable by its colour and large shallow pores, and microscopically by the urniform basidia and smooth, globose spores. This is the type species of the genus *Trechispora* Karst., unfortunately named because Karsten thought that the spores were rough. When type material was examined it was found that the spores were smooth, as described above. Rogers has emended the genus to include all resupinate species, with whatever hymenial form, which have urniform basidia.

Trechispora coronifera (v. Höhn. & Litsch.) Rogers & Jackson in *Farlowia*, **1**, 282, 1943.

Corticium (*Gloeocystidium*) *coroniferum* (v. Höhn. & Litsch.) Wakef. & Pears. in *Trans. Brit. mycol. Soc.* **6**, 140, 1919.

This fungus, referred to *Trechispora* by Rogers and Jackson because of its urniform basidia, was collected again by S. Batko on rotten decorticated wood, probably pine, at Findogask camp, near Perth, in February 1948. The appearance when dry is much like that of *Pellicularia subcoronata* (v. Höhn. & Litsch.) Rogers. Among the corticioid species of *Trechispora* this one is distinguished by the presence of gloeocystidia and by the small, usually curved spores. Embedded in the tissue in the Perth gathering are some rather large crystals of mineral matter.

Sistotrema ericetorum Bourd. & Galz. in *Bull. Soc. mycol. Fr.* **30**, 272, 1914, as subspecies under *S. confluens*.

Sporophore either effused or forming small spathulate pilei, at first white, then becoming yellowish, very soft and thin. *Hymenium* borne on small, slender teeth. *Flesh* soft, fragile, consisting of hyaline hyphae, very thin-walled, which collapse when dry and are then very difficult to make out: *hyphae* 1·5–4 μ in diameter, with clamp-connexions. *Basidia* irregularly urniform, 12–20 × 4–6 μ; only four sterigmata seen in this material. *Spores* elliptical or ovate, with a minute basal apiculus, 3·5 × 2–2·5 μ.

Attached to debris on the ground, Lincolnshire, comm. Miss G. Waterhouse, October 1946.

This plant differs from *S. confluens* in its subresupinate habit. Only this one collection has been seen which could be so referred.

Acia stenodon (Pers.) Bourd. & Galz. in *Bull. Soc. mycol. Fr.* **30**, 256, 1914.

Effused in large patches, waxy, closely adherent, when young and fresh whitish and somewhat translucent, later becoming Warm Buff; when dry

Ochraceous-Tawny to Cinnamon and horny in texture, margin whitish, radiating, fibrillose, narrow. *Spines* at first whitish, subhyaline, then ochraceous or tawny, 1–3 mm. long, slender, very crowded, entire or fimbriate at the apex, sometimes branched. *Hyphae* very closely crowded (hence the horny texture when dry), 2–2·5 μ in diameter. *Basidia* clavate, very small. *Spores* white, cylindric-elliptical with one side depressed, or allantoid with two polar guttules, 4–4·5 × 1·5–2 μ.

On decorticated wood, Blaise Castle, Bristol, April 1923; on old log, Cowdray Park, Sussex, A. A. Pearson, November 1943; on oak, Gospel Green, near Haslemere, September 1945.

A. stenodon var. *nodulosum* (Fr.) Bourd. & Galz. is distinguished from the type especially by its nodulose habit and longer spines, due no doubt to the fact that it is usually found on vertical surfaces. The variety was recorded by Rea in *Brit. Basid.* p. 642, but the typical form had not then been observed. Specimens of the variety have been seen as follows: on beech, Co-operative Woods, Abbey Wood, St John Marriott, December 1919; Abbey Wood, C. H. Grinling, February 1926; Henley, Sussex, A. A. Pearson, September 1945.

Odontia corrugata (Fr.) Bourd. & Galz., *Hym. Fr.* p. 433, 1928.

O. junquillea Quél. in *Bull. Soc. Bot. Fr.* **25**, 290, 1878.

This species was recorded by Carleton Rea in *Trans. Brit. mycol. Soc.* **12**, 222, 1927, under the name *O. junquillea.* It was there said to be common, probably because Bourdot stated in *Hym. Fr.* that it was the most common *Odontia* in his district of France. In this country it does not appear to be so common, but as it evidently occurs usually early in the year it may not have been often observed. The following collections have been received at Kew: Wyre Forest, Worcestershire, Carleton Rea, May 1919; Lessness Woods, Woolwich, C. H. Grinling, February 1920; on rotten oak wood, near Cambridge, E. J. H. Corner, February 1924, also on wood and on a bramble twig, February 1925; Lessness Woods, Woolwich, A. A. Pearson, February 1926.

Asterostroma laxum Bres. ex Bourd. & Galz. in *Bull. Soc. mycol. Fr.*, **36**, 46, 1920.

Effused very thin, dry and soft. *Hymenium* from Pinkish Buff to Avellaneous, pulverulent under the lens, margin whitish, fimbriate, with

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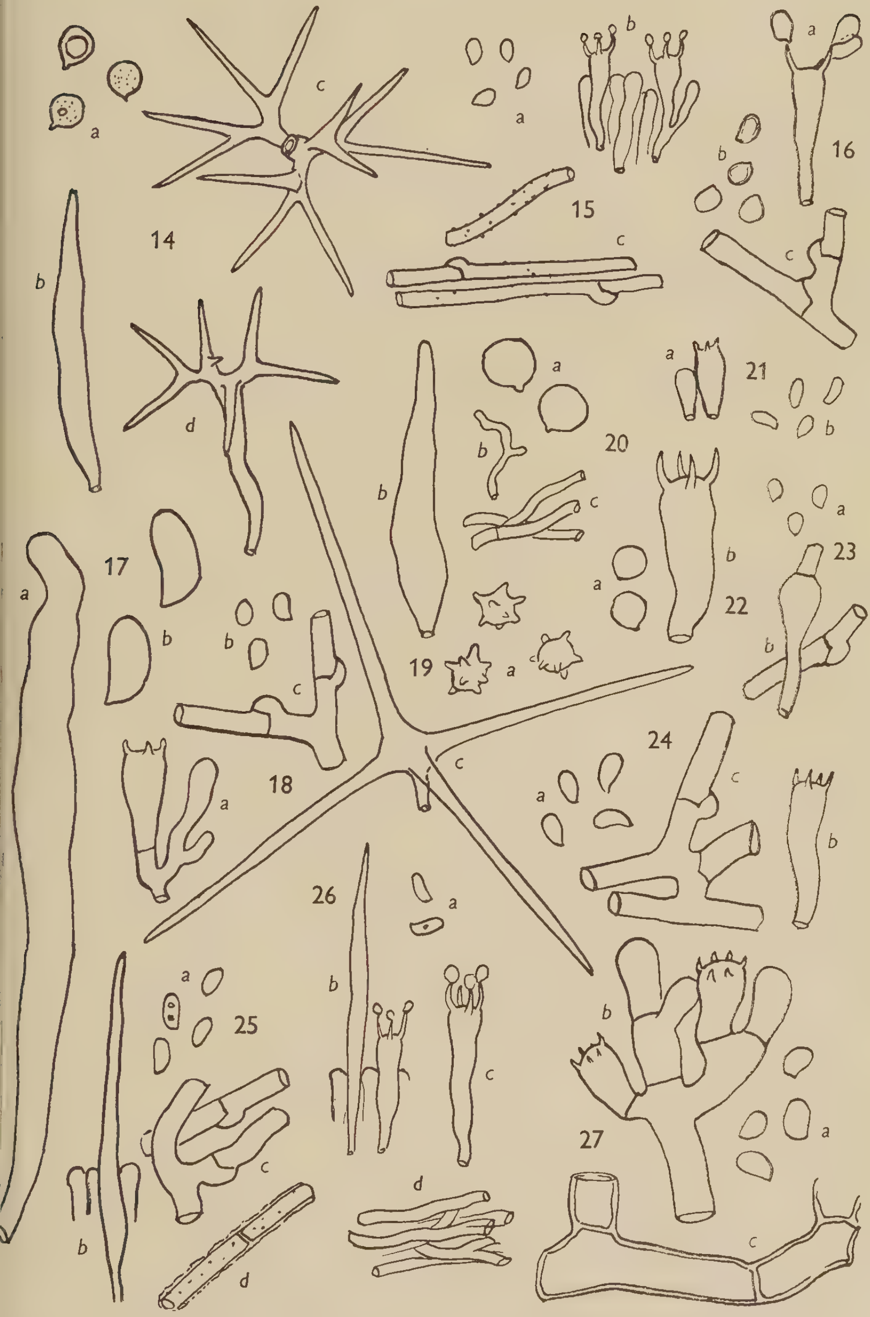
Legends to Figs. 14–27

Fig. 14. *Asterostroma laxum.* *a*, spores; *b*, gloeocystidium; *c*, *d*, stellate setae. (×650.)
Fig. 15. *Corticium fuscostratum.* *a*, spores; *b*. basidia; *c*, basal hyphae.
Fig. 16. *Coniophora mustialaensis.* *a*, basidium; *b*, spores; *c*, hyphae.
Fig. 17. *Corticium* (*Gloeocystidium*) *leucoxanthum.* *a*, gloeocystidium; *b*, spores.
Fig. 18. *C. filium.* *a*, basidium; *b*, spores; *c*, hyphae.
Fig. 19. *Asterostroma medium.* *a*, spores; *b*. gloeocystidium; *c*, stellate seta.
Fig. 20. *Corticium Rickii.* *a*, spores; *b*, paraphysis; *c*, hyphae.
Fig. 21. *C. byssinellum.* *a*, basidium; *b*, spores.
Fig. 22. *C. pulchrum.* *a*, spores; *b*, basidium.
Fig. 23. *C. amianthinum.* *a*, spores; *b*, hyphae, showing ampulliform swelling.
Fig. 24. *C. tessulatum.* *a*, spores; *b*, basidium; *c*, hyphae.
Fig. 25. *C. ochraceo-fulvum.* *a*, spores; *b*, cystidiole; *c*, *d*, hyphae.
Fig. 26. *C. subseriale.* *a*, spores; *b*, cystidiole; *c*, basidium; *d*, hyphae.
Fig. 27. *Pellicularia pruinata.* *a*, spores, *b*, cluster of basidia; *c*, basal hypha.



Figs. 14–27. (All figures, except Fig. 14, × 800.)

sometimes brownish mycelial cords extending upwards. *Hyphae* hyaline, septate, without clamp-connexions, 2–5 μ in diameter. *Stellate bodies* rather small for the genus, consisting of a main axis from which radiate two or three rays, these again forked once or twice; main axis up to 6 μ thick, rays 20–35 × 2–3 μ, often arranged in two symmetrical groups on either side of the axis. *Basidia* hyaline, clavate, with granular contents, 7–8 μ wide, with four short sterigmata. Very few *gloeocystidia* seen, hyaline, elongated fusiform, *c.* 60 × 7 μ. *Spores* hyaline, smooth, globose, with a basal apiculus, and containing one large guttule, 7–9 μ in diameter, sometimes broader than long. (Fig. 14 *a–d.*)

On rotten wood, Hurt Hill Wood, Hindhead, September 1932; on very rotten wood, Henley Woods, Sussex, A. A. Pearson, December 1938.

Specimens of this species have also been seen from Femsjo, Sweden. It is distinguished from *A. andinum* Pat. by the much smaller and more slender stellate bodies and by their somewhat symmetrical form, with the branches arranged in two groups, antler-like, at the top of the central axis.

Asterostroma medium Bres. in *Ann. mycol.*, *Berl.*, **18**, 50, 1920.

Effused in broad, membranous, separable sheets, soft, thin, Cinnamon-Buff or pale Clay-Colour, with a delicate, whitish or pinkish buff bloom where fertile; margin spreading, fibrillose, similarly coloured. *Hymenium* loose, pulverulent, arising in patches here and there over the subiculum. *Basidia* clavate, hyaline, 18–20 × 5 μ, with four slightly curved sterigmata about 5 μ long. *Hyphae* hyaline, thin-walled without clamp-connexions, 2–4·5 μ in diameter. *Stellate bodies* yellow-brown, when fully developed with three to six long, slender, pointed rays, usually simple but occasionally forked towards the apex, up to 80 μ long, radiating from a central cell which is occasionally but not markedly swollen. *Gloeocystidia* more or less fusiform, 30–60 × 8–10 μ. *Spores* hyaline, subglobose, and slightly angular or nodulose with short, blunt conical protuberances, (4·5–)5–6 μ in diameter (without spines), often one-guttulate, amyloid. (Fig. 19 *a–c.*)

On the brickwork of a fire-hydrant drain, Princes Risborough, Bucks., K. St G. Cartwright, November 1943; on plaster behind a window-shutter, Dublin, Eire, P. O'Connor, May 1931; on a deal plank, Bicester, Oxon., A. A. Pearson, January 1948.

The specimens cited were determined originally as *A. ochroleucum* Bres., but re-examination and comparison with the type specimens indicates that they are better referred to *A. medium.* The two species are very close and perhaps may be only forms of one species, but there is a distinct difference in the spores. In *A. ochroleucum* the spore is globose, with fairly numerous blunt spines (or rather pegs) radiating outwards like the spokes of a wheel. In *A. medium* the protuberances from the spore-wall are fewer and more conical, and the spore appears to be angularly nodose, like those of some species of *Inocybe*. The point made by Bourdot and Galzin, that the stellate setae in *A. ochroleucum* have a dilated central portion while in *A. medium* the centre is not at all or very little swollen, does not hold, since in each species both types of setae occur. *A. laxum* differs in the smooth pores and in the form of the stellate setae. *A. cervicolor* (B. & C.) Massee, fairly common species of North America, is similar as to colour but iffers in having spores which are slightly more elliptical and minutely chinulate instead of aculeate or nodular.

Coniophora Betulae (Schum.) Karst. in *Hedwigia*, **35**, 174, 1896.

Effused, thin, dry, more or less separable but sometimes only in fragments, t first soft and floccose, later more membranaceous. *Hymenium* at first oose and pulverulent or granular under the lens, later more compact, chraceous to Clay-Coloured or Tawny Olive, margin paler and byssoid r arachnoid. *Hyphae* hyaline, or the basal hyphae yellowish, irregular nd very variable in size, 3–7 μ in diameter, septate, without clamp-onnexions, sometimes united to form cords, often encrusted with crystals f mineral matter. *Basidia* narrowly clavate, 40–50 × 8 μ, with four curved terigmata 8–10 μ long, projecting above the hymenial surface when ature. *Spores* elliptical with a small basal apiculus, hyaline to yellowish, 0–14 × 6–7·5 μ.

On a branch of beech on the ground, Banstead Downs, Surrey, S. J. Hughes, January 1948; on poplar, Bolton Percy, Yorks., W. G. Bramley, March 1950.

Very closely related to *C. arida*, which it resembles in the dry, not fleshy, texture. It differs from *C. arida* in being usually more floccose, with a more istinct, arachnoid margin, and in the more irregular, encrusted basal yphae.

Coniophora mustialaensis (Karst.) Massee in *J. linn. Soc.* **25**, 139, 1889.

Hypochnus mustialaensis Karst., in *Not. Faun. Fl. Fenn.* **11**, 222, 1871.

Sporophore effused, very thin and soft, with a loose, whitish subiculum. *Hymenium* not continuous, at length minutely granular, with loose, ulverulent tufts, olive (Buffy Citrine to Medal Bronze). *Hyphae* hyaline o yellowish, thin-walled, with clamp-connexions at the septa, 2·5–4–5 μ n diameter. *Basidia* clavate, hyaline, 25–30 × 6 μ, with four sterigmata –5 μ long. *Spores* broadly elliptical with the inner side depressed, yellowish-live when viewed in water, but becoming deep violet when treated with dilute potash solution, smooth, rather thick-walled, with a minute but istinct lateral basal apiculus, 4–5 × 3–3·5 (–4) μ. (Fig. 16 *a–c*.)

On very rotten decorticated wood, Arundel Park, Sussex, October 1928.

This species is evidently very rare in Europe and was not known to ourdot and Galzin, who confused it with *Caldesiella viridis*. The specimen ted has been compared with Karsten's type, with which it agrees in very respect. Rogers and Jackson, *Farlowia*, **1**, 277, 1943, have stated hat *Coniophora cyanospora* Rogers is synonymous. It is evidently very close o *C. mustialaensis*, but before this synonymy is accepted it would seem esirable to examine more material. Rogers described the spores of his pecies as deep, dull blue-violet at first, and said that they were unchanged n potash solution, whereas the spores in our material and in the type pecimen of Karsten's *Hypochnus* the spores are olivaceous, and become blue nly when treated with an alkali.

Aleurodiscus apricans Bourd. in *Rev. sci. Bourbon*, 1910, p. 5; Bourd. & Galz., *Hym. Fr.* 1928, p. 332.

Sporophore effused, at first in small patches which later become confluent, with no definite margin, yellowish or with a faint pinkish buff tinge (when dry), thin, pulverulent under the lens. *Hymenium* consisting of basidia, pseudophyses and acanthophyses, with also undifferentiated hyphal ends. *Hyphae* indistinct, hyaline, 2–2·5 μ in diameter. *Young basidia* with highly refractive contents, giving a yellowish colour when treated with dilute potash solution, clavate, 35–50 × 13–15 μ. *Mature basidia* collapsed and difficult to see. *Acanthophyses* irregular, clavate or sometimes moniliform, 30–35 × 8–9 μ, beset with small spines towards the apex. *Pseudophyses* similar but smooth. Spores elliptical, amyloid, very minutely echinulate, 13–16 × 8–11 μ. (Fig. 5 *a–c*.)

On dead stems of *Rubus fruticosus*, Guernsey, Channel Islands, M. B. Ellis, September 1948.

The species in colour and habit is not unlike *Aleurodiscus aurantius*, but differs in the smaller spores and the aculeate paraphyses (acanthophyses).

Aleurodiscus aurantius (Pers. ex Fr.) Schroet., *Pilz. Schles.* **1**, 429, 1889.

Thelephora aurantia Pers. ex Fr., *Syst. Myc.* **1**, 445, 1821.

Sporophore indefinitely effused, closely adnate, thin, waxy when fresh. *Hymenium* Flesh-Colour, Ochraceous- or Pinkish-Buff, sometimes granular, pruinose or sometimes, when seen under the lens, appearing as if sprinkled with shining particles, cracked when dry; margin concolorous or whitish, very narrowly fimbriate. *Hyphae* thin-walled, indistinct, 2–4·5 μ. *Basidia* cylindrical or clavate, with pinkish and granular contents when young, becoming empty and consequently hyaline after the spores are shed, 50–70 × 15 μ; sterigmata two to four, strongly incurved, 12–20 μ long, 4 μ wide at the base. *Paraphyses* (pseudophyses) at first not very distinct from the young basidia, later either moniliform with two or three swollen portions, or drawn out to a point at the apex. There also occur in the hymenium narrow, flexuous hyphal ends, simple or slightly branched, sometimes swollen at the apex. *Spores* broadly elliptical, with a lateral basal apiculus, amyloid, mostly smooth, but sometimes very finely punctate-aculeate, 17–19 × 12–15 μ. (Fig. 4 *a–d*.)

On a small twig, Ipplepen, Newton Abbot, Devon, Miss J. C. Eyre, January 1922; on a rose twig, Woolwich, C. H. Grinling, November 1923; on rose stems, Exeter, P. H. B. Talbot, September 1947.

Aleurodiscus delicatus Wakef., sp. nov.

Effusus, tenuissimus, albidus vel dilute persicinus, margine similari. Hymenium fere laxum, pulverulentum. Hyphae parum distinctae, tenues. Basidia juvenilia obclavata, flexuosa, apice rotundata, demum subcylindracea, obovata vel amphoriformia, medio saepe angustata, 25–30 × 10–11 μ, sterigmatibus curvatis, subulatis, 8–9 μ longis, basi 2 μ crassis. Sporae ellipticae, uno latere depressae, minute denseque echinulatae, amyloideae, 13–15 × 7–8 μ, basi apiculatae. Acanthophyses clavatae vel piriformes, sursum papillis elongatis munitae, plurimarum Mycenae specierum cheilocystidiorum instar; cystidia (sine papillis) 22–30 × 6·5–9 μ papillae 2–3 μ longae. Adsunt quoque inter hyphis corpora crystallina rhomboidea.

Hab: in folliis emortuis *Cladii marisci*, Wheatfen Broad, Norfolk, E. A. Ellis, February, 1948.

Entirely resupinate, effused in small oval patches, with no distinct nargin, very thin and delicate, whitish or pale peach-pink. *Hymenium* ose, pulverulent under a lens. *Hyphae* slender, not distinctly seen. *Young asidia* obclavate, somewhat flexuous, with rounded apex. *Older basidia* ubcylindrical to urniform or amphoriform, i.e. constricted somewhat in he middle and swollen below, occasionally at length with a transverse eptum, 25–30 × 10–11 μ; sterigmata four, curved, subulate, 8–9 μ long nd about 2 μ thick at the base. *Spores* elliptical, depressed on the inner ide, with a small oblique basal apiculus, the wall minutely and closely chinulate, strongly amyloid. There are also present in the hymenium umerous rounded or pear-shaped cells (acanthophyses) with terminal rush-like appendages, resembling the cheilocystidia of some species of *Iycena*. The tissues are full of rhomboidal crystals, which obscure the yphae. (Fig. 3 *a–c*.)

On dead leaves of *Cladium mariscus*, Wheatfen Broad, Norfolk.

The large basidia and the large, rough, amyloid spores place this fungus 1 the genus *Aleurodiscus*. It differs from all other species of *Aleurodiscus* itherto described in the very delicate texture, like some species of *orticium*, and in the peculiar shape of the basidia. The figure of *C. obsoletum* itsch. *Ann. mycol., Berl.*, **39**, 119, (1941) shows somewhat similar pitcher-haped basidia and large spores, and this species too may prove to belong to *lleurodiscus*. In *Corticium obsoletum*, however, the spores are subglobose or roadly elliptical, 10–14 μ in diameter or 13–16 × 10–14 μ, that is, much roader than the spores of the present species, and it is not stated whether hey are amyloid. It was found on rotten coniferous wood.

leurodiscus Oakesii (Berk. & Curt.) Cooke in *Grevillea*, **3**, 172, 1875.

Sporophores at first rounded, 3–5 mm. in diameter, with a pale definite nargin, which is free and at length upturned slightly showing the whitish asal tissue, later becoming confluent and forming irregular lobed patches. *Iymenium* compact, smooth, Avellaneous, margin paler. *Hyphae* 2·5–3 μ n diameter, hyaline. *Basidia* very large, 70–90 (–110) × 20–22 μ, with four ubulate, curved sterigmata 25 μ long and 4–5 μ wide at the base. *Para-hyses* of varying form; some are acanthophyses, irregular, flexuous, more r less cylindrical with blunt apex, 5–7 μ wide, with scattered blunt pro-ections at or near the apex; others (pseudophyses) smooth and cylindrical r moniliform in the upper part. *Spores* elliptical with a distinct lateral piculus, strongly amyloid, 19–23 × 14–16 μ, the wall appearing smooth vhen not stained, but minutely echinulate when stained with Melzer's olution. (Fig. 2 *a–d*.)

On dead twigs of beech, Berry Pomeroy, South Devon, September 935.

The species differs from *A. amorphus* in growing on hardwood trees, not n conifers, and in the confluent habit. Microscopically it is characterized y the presence of acanthophyses, and by the spores, which have been sually described as smooth, but which when stained with Melzer's reagent re seen to be distinctly, though minutely, echinulate.

Corticium amianthinum Bourd. & Galz. in *Bull. Soc. mycol. Fr.* **27**, 260, 1911.

Broadly effused, fragile white to cream coloured or pale ochraceous; subiculum chalk-white, showing at the edge as a silky, radiating margin. Hymenium cream (Light Buff), smooth or slightly granular, cracked when dry, showing the white subiculum in the interstices. *Hyphae* for the most part regular, sparingly septate, with clamp-connexions, 2–4 μ, the basal hyphae occasionally with ampulliform swellings at the septa up to 7 μ diameter. *Basidia* hyaline 15–18 × 4·5–5 μ, with two to four short, straight sterigmata. *Spores* hyaline, smooth, ovate-elliptical with a pointed basal apiculus and sometimes slightly curved at the base, 3–5 × 2–2·5 μ. (Fig. 23 *a–b*.)

On the ground, covering small twigs, dead leaves, etc., which are matted together by the mycelium, Queen's Cottage grounds, Royal Botanic Gardens, Kew, Surrey, September 1945.

In habit, the fungus resembles *C. fastidiosum*, matting together all kinds of vegetable debris and often extending for a considerable area. Its occasional ampulliform swellings of the hyphae place it in the section *Humicola* of Bourdot & Galzin, but it differs from most members of that section in the smooth spores. Bourdot and Galzin later (*Hyménomycètes de France*, 1928) regarded it as a subspecies of *C. albo-ochraceum* Bres. From *C. byssinellum*, which is closely related, it differs in the shape of the spores, and in the abundant white subiculum, which is in sharp contrast to the fragile, deep cream-coloured hymenium,.

Corticium byssinellum Bourd. in *Rev. sci. Bourbon*, **23**, 11, 1910; *Hyménomycètes de France*, 232, 1928.

Pure white, indefinitely effused, forming a very delicate, cobweb-like, easily separable film on mosses or dead leaves, the subiculum forming here and there fine strands which may extend beyond the margin. *Hymenium* pulverulent under the lens, loose. *Hyphae* hyaline, thin-walled, sparingly septate, with well-developed clamp-connexions, 2–4 μ in diameter, occasionally with bulb-like swellings up to 6 μ in diameter below the cross-walls. *Basidia* developing in corymbose tufts, small, clavate, (8–) 10–12 × 4 μ, with two to four short sterigmata. *Spores* hyaline, narrowly elliptical or oblong, with a basal apiculus, 3–4 (–5) × 1·5–2 μ. (Fig. 21 *a–b*.)

On dead bracken stems, Broadwater Forest, Sussex, A. A. Pearson, November 1923; on dead beech leaves, Epping Forest, Essex, October 1923; on mosses, Hackfall, Grewelthorpe, Yorks, September 1948; on moss, Southfield, Co. Down, Northern Ireland, R. W. G. Dennis, September 1948.

In dried material the structure is difficult to make out, because the very thin-walled hyphae are apt to collapse, and also because the tissue is full of small crystals of mineral matter. This species also belongs to the section *Humicola* of Bourdot and Galzin, but differs from *Corticium amianthinum* in the smaller and more oblong spores and in the delicate, separable, film-like texture. In appearance it is not unlike *C. Galzini* Bourd., but that species grows on pine and has no ampulliform swellings in the hyphae.

rticium filium Bres. in *Ann. mycol., Berl.*, **6**, 43, 1908.

Effused in small patches, separable. *Subiculum* cobweb-like, thin, itish to pale yellowish. *Hymenium* smooth, continuous, forming a thin, gile pellicle, yellow (Pale Orange Yellow to Orange Buff). *Hyphae* egular, hyaline or with a yellowish incrustation, 1·5–4–6 μ in diameter, otate with conspicuous clamp-connexions and sometimes with ampulli-rm swellings at the septa; the subhymenial hyphae thin-walled, basal phae thicker-walled and sometimes united to form slender, cord-like ands. *Basidia* clavate, hyaline, 15–20 × 6–7 μ with two to four sterig-ata. *Spores* elliptical, hyaline, smooth 4–5(–6) × 2·5–3 μ (according to urdot and Galzin 4·5–7·5 × 3–4·5 μ). (Fig. 18 *a–c*.)

Beneath a tuft of moss (*Campylopus* sp.), Broadwater Forest, Sussex, A. Pearson, August 1927.

Except in the yellow colour this species seems very close to *Corticium ssinellum*, and would be better placed in the section *Humicola* than in ction *Pellicularia*, where it is found in Bourdot and Galzin. It differs m *Corticium byssinellum* in the more compact hymenium and in the larger d more conspicuous spores and hyphae. *C. tessulatum* Cooke is somewhat nilar in appearance when dried, but differs in spores and in the much oader hyphae; moreover, it has not been recorded as growing on mosses.

rticium pulchrum Lundell in Fungi Exsicc. Suec. 1035 (1941).

C. atrovirens (Fr.) Fr. var. *spora majore* Bourd. & Galz., *Hyménomycètes de France*, p. 201, 1928.

Effused, soft, tomentose-pulverulent, at first developing in small, egular patches and looking like a Hyphomycete, bluish green (when sh Bluish Gray-Green or Deep Bluish Gray-Green to Russian Green). *phae* pale greyish-blue by transmitted light, 2–2·5(–3) μ in diameter, ther straight, branched at right-angles, septate at rather long intervals, thout clamp-connexions. *Basidia* clavate, coloured like the hyphae, th granular contents, 30–35 × 5–7 μ, with two to four slightly curved rigmata 4–5 μ long. *Spores* sub-globose, with a somewhat conical base, 6·5 × 4·5–5 μ, bluish, with a large oil-globule. (Fig. 22 *a–b*.)

On the under side of fallen branches of dicotyledonous trees, St George's ll, Weybridge, Surrey, A. A. Pearson, November 1918.

Closely resembling *C. atrovirens*, but differing in the larger spores, which not so regularly globose, and also in the slightly larger basidia.

rticium tessulatum Cooke in *Grevillea*, **6**, 132, 1878.

C. illaqueatum Bourd. & Galz. in *Bull. Soc. mycol. Fr.* 27, 238, 1911.

Widely effused, loosely adherent, consisting of a spreading, white, silky-rillose subiculum overlaid by a fragile, smooth hymenium, which cracks o irregular patches when dry, and shows the subiculum in the inter-ces. *Hymenium* when fresh wrinkled or bullate, or with a meruloid pearance, white to cream-coloured, when dry quite smooth, pellicular, am to pale alutaceous (Warm Buff), margin radiating, white, fibrillose. *phae* distinct, thin-walled, loosely interwoven, with clamp-connexions; hymenial hyphae 2–3 μ basal hyphae 3–4(–6) μ in diameter. *Basidia* rrowly clavate, closely packed, 20–40 × 5–6(–7) μ, with two to four short sterigmata. *Spores* hyaline, smooth, elliptical or ovate, attenuated below into a rather long apiculus (tear-drop-shaped), 5 × 2·5–3 (–4) μ. (Fig. 24 *a–c*.)

On rotten, decorticated wood, Epping Forest, October 1917; Frant Bottom, Sussex, A. A. Pearson, December 1926; Henley Woods, Sussex, A. A. Pearson, December 1938.

This fungus belongs in the section *Pellicularia* of *Corticium*, as defined by Bourdot and Galzin, and is characterized by the loose subiculum from which the hymenium readily separates, and by the continuous hymenium, meruloid when fresh and cracked when dry. Microscopically it is distinguished from its allies by the tear-drop-shaped spores. Bourdot and Galzin under their *C. illaqueatum* distinguish several forms, of which f. *communis* appears to agree with the British specimens. The material of *C. tessulatum* Cooke is very poor, but the general appearance is similar, and similar spores have been found in it. There seems no reason to doubt the synonymy given by Rogers and Jackson, *Farlowia*, **1**, 281, 1943, and the name *C. tessulatum* Cooke must therefore be adopted as the earlier name for this species. The American forms have all been found on conifers, but the European specimens occur on the wood of Dicotyledonous trees.

Corticium fuscostratum Burt in *Ann. Mo. bot. Gdn*, **13**, 299, 1926.

C. ochroleucum Bres., *Fungi Tridentini*, **2**, 58, 1898; nec *C. ochroleucum* (Fr.) Fr. *Epicr.* 557, 1838; nec *C. ochroleucum* (Noack) Burt ex Peltier, *Bull. Univ. Ill. Agric. Exp. Sta.* No. 189, 290, 1915.

Sporophore effused, soft and separable; subiculum brownish (about Ochraceous Tawny), thin and rather loose, fibrillose, extended beyond the hymenium as a pale, fimbriate margin. *Hymenium* cream-coloured, pellicular, sometimes meruloid when fresh, finely cracked when dry. *Hyphae* of subiculum reddish brown, septate, with clamp-connexions, 2–3 (–4) μ in diameter, rather straight and regular, sometimes united to form cords; subhymenial hyphae hyaline, 2–2·5 μ. *Basidia* clavate, small, about 15 × 3–4 μ, with four short sterigmata. *Spores* hyaline, elliptical with the inner side depressed, 4 × 2 μ. (4·5–6 × 2·5–3 *sec.* Bourd. & Galz.). (Fig. 15 *a–c*.)

On bark, probably coniferous, Findogask, near Perth, S. Batko, February 1948; inside pine bark, Findogask, S. Batko, March 1948; on *Betula*, Quarry Ghyll, Masham, Yorks, W. G. Bramley, April 1950.

As pointed out by Rogers and Jackson, *Farlowia*, **1**, 291, 1943, the name *C. ochroleucum* Bres. is untenable because of the existence of the earlier homonym *C. ochroleucum* (Fr.) Fr. This fungus is said to be common in the United States and is apparently fairly widespread on the Continent, but has not previously been seen from this country. It is very easily recognized by the contrast of colour between the tawny subiculum and the cream-coloured hymenium, and by the small, elliptical spores. It usually occurs on pine, but the Yorkshire specimen was on birch.

Corticium laetum (Karst.) Bres. in *Ann. mycol., Berl.*, **1**, 94, 1903.

Hyphoderma laetum Karst. in *Rev. Mycol.* p. 206, 1889.

Irregularly effused, rather soft and fleshy, with no definite margin, bright pink (salmon when moist, paler when dry). *Hymenium* waxy, ontinuous. Hyphae hyaline, the subhymenial ones thin-walled, irregular, ometimes with short segments and somewhat moniliform, basal hyphae ith thicker walls, without clamp-connexions, up to 10 μ in diameter. *asidia* clavate, 8–10 μ wide above, rather long (40–50 μ) and flexuous, ith four sterigmata 7–8 μ long, contents at first granular and refractive. ntermingled with the basidia are slightly branched hyphal ends. *Spores* vate or elliptical, narrowed to a basal apiculus, which is sometimes ightly incurved, hyaline, thin-walled, 12–15 × 7–9(–9·5) μ, contents ightly granular.

Growing over the surface of mud, Thornton-le-Dale, Yorks, P. H. B. albot, April, 1947.

The species is said by Bourdot and Galzin to have rare clamp-con- exions, but these were not seen in our material. The large irregular yphae and large, ovate spores are characteristic. The normal habitat is n dead branches or dead leaves, and the fungus may have spread on to e mud from some vegetable debris. The basidia are difficult to make out ecause there is a deposit of coloured granules in the hymenium.

orticium tuberculatum Karst. in *Hedwigia*, **35**, 45, 1896.

C. lacteum Fr. sensu Bourd. & Galz., nec sensu Burt.

Effused, waxy membranaceous, when fresh milk-white and sometimes eruloid and separable, when dry deeper-coloured (buff to ochraceous) osely adnate, cracked, margin whitish, radiating, fibrillose, sometimes ather wide. *Hyphae* hyaline, without clamp-connexions, branched and osely interwoven, the subhymenial 2–3 μ in diameter, basal up to 6 μ nd abundantly encrusted with small granules. *Basidia* elongated, clavate, osely packed, about 5–5·5 μ wide above, with two to four slightly curved erigmata 4 μ long. *Spores* broadly elliptical or ovate, attenuated at the ase, 4–6 × 3–3·5 μ.

On bark and wood of *Ulmus*, *Alnus*, etc., Roche Abbey, Yorks, S. J. ughes and W. G. Bramley, April 1948; on bark and rotten wood, orcester Foray, September 1921; Baslow, A. D. Cotton, May 1915.

This fungus was included (as *Corticium lacteum*) in Rea's *Basidiomycetae* ith the description taken from Bourdot and Galzin. As pointed out by ogers and Jackson the name *C. lacteum* was probably applied by Fries to ny milk-white *Corticium*. His specimen at Uppsala is *C. bombycinum* and e Lindblad material in Herb. Kew which was examined by Burt is mixture of *C. radiosum* and another species which may be this one. It is est to treat the name *C. lacteum* as a *nomen ambiguum*, and to adopt the ame *C. tuberculatum* Karst., about which there is no doubt. The species to be found during the warmer months, and is characterized by its spores nd by the abundantly encrusted basal hyphae, a feature which, curiously, as not noted by Bourdot and Galzin.

orticium Rickii Bres. in Rick, *Öst bot. Z.* **48**, 136, 1898.

sensu Bourd. & Galz., *Hyménomycètes de France*, p. 213.

Irregularly effused, when fresh waxy, rather thick, dirty white or eyish, here and there somewhat hyaline, becoming thin and hard on drying; margin indefinite. *Hymenium* continuous, waxy, pulverulent with the spores, Light Buff when dry. *Basal hyphae* 3 μ in diameter, septate, with occasional clamp-connexions, very closely agglutinated. *Subhymenial hyphae* 1·5–2 μ in diameter, branched, with free ends extending into the hymenium between the basidia, not easily distinguished. *Basidia* clavate, 30–40 × 7–10 μ, with two to four short sterigmata. *Spores* globose or subglobose, distinctly apiculate at the base, 7·5–9 × 8–10 μ. (Fig. 20 *a–c*.)

On bark, Eridge Park, Sussex, A. A. Pearson, January 1926.

This fungus is closely allied to *Corticium confluens* and resembles it in general appearance. It is, however, distinguished by its constantly more or less globose spores. As pointed out by Bourdot and Galzin, the consistence when fresh is distinctly waxy, not 'membranaceous-soft' as given in the original description. In other respects it agrees with Bresadola's diagnosis.

Corticium subseriale Bourd. & Galz., *Hyménomycètes de France*, p. 219, 1928.

Effused, closely adherent, rather thick, smooth, waxy, greyish when fresh, paler (ochraceous to Glaucous Gray) and cracked when dry. Tissue very compact, made up of closely interwoven hyphae, 1·5–2 μ in diameter, thin-walled, hyaline, said by Bourdot to have scattered clamp-connexions, but these were not seen in the present specimen. *Basidia* elongated, clavate, flexuous, closely packed, 20–30 μ long, 4–4·5 μ wide above, with four curved sterigmata 4–5 μ long. *Spores* cylindrical or slightly curved, with an oblique basal apiculus, 4–5·5 × 1–2 μ. *Cystidioles* present in the hymenium, subulate, acute, 3–4 μ wide in the widest part, projecting up to 38 μ above the surface. (Fig. 26 *a–d*.)

On rotten pine wood, head of Glenmore, Rothiemurchus, Inverness-shire, R. W. G. Dennis, April, 1949.

The species was confused with *C. seriale* Fr. by Bresadola and probably by Fries himself. It differs in the longer and somewhat allantoid spores and in the presence of cystidioles.

Corticium ochraceo-fulvum Bourd. & Galz. in *Bull. Soc. mycol. Fr.* **27**, 257, 1911.

Sporophore effused, closely adnate, arising as small rounded patches but eventually by coalescence producing fairly large sheets, waxy when fresh, becoming hard and rather horny when dry and the hymenium cracking into small areas, showing the whitish subiculum in the interstices; colour very variable, from Ochraceous- or Pinkish-Buff to Cinnamon, Tawny Ochraceous, or sometimes approximately Wood Brown; margin either similar or whitish and radiating. *Hymenium* smooth, more or less tubercular, pruinose under the lens. Tissue consisting of closely interwoven hyphae with large clusters of crystals intermixed. *Hyphae* only distinguishable with difficulty, hyaline, sparingly branched, with clamp-connexions, sometimes encrusted, 2–3 (–4) μ. *Basidia* narrowly clavate, 15–20 × 3–5 μ, with two to four short sterigmata. *Cystidioles* present in hymenium, subulate, subacute, 50–60 × 3–4 μ at the widest part, projecting up to 40 μ. *Spores* yaline, oblong with the inner side flattened, with a slight lateral apiculus, -6 (–7) × 2·5–3 μ. (Fig. 25 *a–d*.)

On bark of *Alnus*, Askham Bog, Yorkshire, W. G. Bramley, October 938 and June 1948; on decorticated wood, Moccas Old Park, Hereford, . A. Pearson, September 1926.

This species is closely allied to the preceding, and in *Hyménomycètes de rance* was placed under *C. subseriale* as a sub-species. *C. ochraceo-fulvum* has, owever, broader and more oblong spores than *C. subseriale*, and is not und on conifers.

orticium asseriphilum Litsch. in *Ann. mycol., Berl.*, **32**, 55, 1934.

Developing at first as small, irregularly rounded patches, later becoming onfluent, waxy when fresh, rather horny when dry and contracting somehat at the margin, thin, closely adherent, Cream Buff or Pinkish Buff, ruinose under the lens. *Hymenium* compact, in older, thicker specimens racked when dry. *Hyphae* very closely interwoven and extremely difficult see, especially in dried material, hyaline, flexuous, thin-walled, 5–3(–4) μ in diameter; no clamp-connexions seen. *Basidia* relatively rge, clavate, 20–25 × 5–6 μ, with two to four slender, somewhat curved erigmata, 4–6 μ long. *Spores* hyaline, smooth, pip-shaped or boataped, sometimes curved, with a rather long, pointed basal apiculus, -8 × 3·5–4 (–4·5) μ, often containing one or more oil-drops. (Fig. 9 *a–b*.)

On bare coniferous wood (apparently worked wood), Hackfall, Grewelorpe, Yorkshire, W. G. Bramley, April 1950.

The species was described by Litschauer from the Tyrol and has been corded from Sweden (Lundell & Nannfeldt, Fungi Suec. Exsicc. 1036*a* d 1036*b*). It seems to prefer worked coniferous wood, such as fencing aterial, and is characterized by its close texture (horny when dry), its lour, and the large, somewhat boat-shaped spores with a marked, ongated basal apiculus.

In a recent paper (*Canad. J. Res.* C, **28**, 526, 1950) Prof. H. S. Jackson as noted that *C. asseriphilum* Litsch. is the same as *C. Pseudotsugae* Burt. this is so Burt's name will have priority.

orticium pulverulentum Litsch. in *Öst. bot. Z.* **88**, 112, 1939.

Peniophora pulverulenta (Litsch.) H. S. Jackson in *Canad. J. Res.* C, **28**, 532, 1950.

Effused, thin, waxy-gelatinous or almost mucilaginous (in texture like me species of *Sebacina*), greyish, pruinose under a lens, when dry rather orny and greyish ochraceous, with no distinct margin. *Hymenium* for the ost part smooth, closely adpressed, but here and there are fleshy cords erect projections which are also fertile. Basal hyphae 2–3 μ in diameter, osely agglutinated and indistinct, no clamp-connexions seen. *Basidia* lindrical, 30–38 × 6–7 μ, when mature projecting about 10 μ or more ove the surface of the hymenium, with four sterigmata 5 μ long and 5 μ thick at the base. *Spores* oblong-ellipsoid, slightly flattened on the ner side, with a lateral basal apiculus, 6–7·5–9 × 5–6 μ (usually 7·5 × 5 μ) d marked with fine longitudinal striations forming a loose spiral. These riations are visible in fresh material mounted in water, but are obliterated by the use of potash for swelling dried material, and hence may be easily overlooked. (Fig. 8 *a*, *b*.)

On rotten wood of a dicotyledonous tree, Babraham, near Cambridge, E. J. H. Corner, April 1926.

This interesting fungus was put aside for description as a new species under the name *Corticium striatosporum*, and was so included when the present paper was sent in for publication. A few days later however there arrived a reprint of the paper by Prof. Jackson cited, and it was realized from his figures that his *Peniophora pulverulenta* must be the same species. Unfortunately Litschauer did not see the striations of the spores, but Jackson observed this character in type material examined, and also found that curious capitate or lobed cystidioles are present, hence his reference to *Peniophora*. He associates it with *P. rimicola* and *P. chordalis*. In the present material no cystidioles have been detected, and since, as emphasized by Jackson, it may be necessary eventually to segregate this and related species as a distinct genus, there seems to be no particular advantage in making a new combination under *Peniophora*. Jackson describes the spores as 8–12 μ long but there seems no reason to doubt that the British specimen belongs to the same species.

In addition to the remarkable spores, the species is characterized by its somewhat gelatinous texture and by the presence of superficial cords or fusiform projections which sometimes produce a reticulate appearance.

Corticium reconditum Jackson in *Canad. J. Res.* C, **26**, 154, 1948.

Sporophore effused in large patches, thin, closely adnate, hypochnoid and when dry resembling certain species of *Pellicularia*, colour when fresh from Brussels Brown to Clay-colour, paler when dry (Isabelline or pallid) with no distinct margin. *Hymenium* compact when fully developed, rather waxy, thinning out and becoming more pulverulent towards the margin. *Hyphae* closely interwoven, pale brown, rather wavy and irregular, branched and frequently septate, with clamp-connexions, 2–2·5–3 μ in diameter. *Basidia* hyaline, shortly clavate or subpyriform, sharply narrowed at the base, 15–20 × 6·5–8 μ, with four slightly curved sterigmata up to 10 μ long. *Spores* somewhat almond-shaped or boat-shaped, pointed at each end and with the inner side depressed, hyaline, 8–9 × 4–5 μ. (Fig. 12 *a*, *b*.)

On pine and birch logs, Broadwater Forest, Sussex, A. A. Pearson, December 1923 and November 1924; on decorticated wood, without locality A. A. Pearson, November 1926; on decorticated wood, Lessness Woods, Kent, A. A. Pearson, October 1927 (a poor specimen, not well developed).

When the first specimens were received they were put aside as a 'brown *Corticium*' which did not fit any of the known European species and might prove to be undescribed. As soon as Prof. Jackson's paper was received his figures of *C. reconditum*, described from Ontario, Canada, were recognized as being the same as our 'brown *Corticium*'. The colour, the curiously shaped spores, and the short, sometimes pyriform basidia are characteristic features of this fungus. It would appear to be here a winter species.

Corticium (Gloeocystidium) analogum (Bourd. & Galz.) Wakef., comb.nov.

Gloeocystidium analogum Bourd. & Galz. in *Bull. Soc. mycol. Fr.* **28**, 366, 1912.

Widely effused, closely adherent and following the inequalities of the bark, smooth, deep cream to buff-coloured (Pale Orange Yellow), with narrow, whitish margin of radiating hyphae. *Hymenium* compact, pulverulent under the lens, sometimes cracked when dry but not markedly o. *Hyphae* thin-walled, closely compacted and very indistinct, about 2–4 μ n diameter. *Gloeocystidia* very numerous (the flesh in fact seems to be mainly made up of gloeocystidia, which arise at different levels from the base upwards), elongated, wavy and rather irregular, subfusiform, or cylindrical but inflated towards the base, tapering gradually to a point bove, up to 110 μ in length and 8–10 μ wide, with granular oily contents which exude in crushed mounts as numerous oil-drops. *Basidia* clavate, –8 μ wide, with four curved sterigmata 6–7 μ long. *Spores* broadly lliptical or subglobose, rugulose, 8–9 × 7–8 μ appearing slightly yellowish by transmitted light. (Fig. 13.)

On bark, possibly of beech, Epping Forest, October 1936.

This species is said to have a strong, sweetish smell when fresh, but this was not noted in the single specimen collected. The spores in shape and ize resemble those of *C. confluens*, but differ in the roughened wall, which s best described as rugulose rather than warted. The fungus has also been ecorded from Sweden.

Corticium (Gloeocystidium) geogenium Bres. in *Ann. mycol., Berl.*, **1**, 99, 1903.

Gloeocystidium inaequale v. Höhn. & Litsch. in *S.B. Akad. Wiss. Wien,* **116**, Abt. 1, 826, 1907.

Peniophora albostraminea Bres. in *Mycologia,* **17**, 69, 1925.

Effused, thin, pure white at first but eventually cream or buff-coloured, losely adherent, margin indefinite. *Hymenium* somewhat pulverulent, carcely waxy, when dry appearing under the lens somewhat poroid or inely cracked. *Hyphae* frequently septate and much branched, with clamp-onnexions, 3–5 μ in diameter. *Basidia* clavate, 20–27 × 5–7 μ, with two to our sterigmata 4–5 μ long, intermixed with flexuous hyphal ends. *Spores* roadly elliptical smooth, hyaline, frequently uniguttulate, 6–7 × 4–5 μ. *Gloeocystidia* cylindrical or very slightly fusiform, obtuse at the apex, 5–120 × 8–10 μ, protruding up to 80 μ above the surface of the hymenium. Fig. 10 *a, b*.)

On a very decayed pine log, Ashurst Park, Kent, A. A. Pearson, December 1922; on bark, Ashdown Forest, Sussex, A. A. Pearson, November 1926; Peebles, Scotland, J. B. Cleland, January 1938; on pine wood and bark, Yazor, Herefordshire, S. Batko, December 1948.

This species is probably more common than would appear from the few ecords, but it is evidently a winter form, and may easily be passed over s resembling several other whitish species. It is characterized especially y the very long, often flexuous gloeocystidia, which may originate in the asal tissue and project considerably beyond the hymenium. The spores, which are not amyloid, vary somewhat in form. While usually elliptical or oblong, and not markedly depressed on the inner side, in a specimen in Brinkmann, Westf. Pilze, No. 102, which is cited by von Höhnel and Litschauer, they are almost globose. The synonymy given above was established by Rogers and Jackson in *Farlowia*, **1**, 311, 1943.

Corticium (**Gloeocystidium**) **granulosum** Wakef., nom.nov.

Gloeocystidium furfuraceum (Bres.) v. Höhn. & Litsch. in *Wiesner Festschrift*, p. 68, 1908.
Hypochnus furfuraceus Bres., *Fungi Trid.* **2**, 97, (tab. 208, fig. 2), 1892, non *Corticium furfuraceum* Bres. in *Mycologia*, **17**, 69, 1925.

Irregularly effused, very thin, pure white or greyish white, margin similar. *Hymenium* not continuous, pulverulent, frequently developed in small tufts, giving a minutely granular appearance as seen under the lens. *Hyphae* indistinct, about 2 μ in diameter. *Basidia* narrowly clavate or often somewhat urniform, 15–30 × 4–6 μ, with two to four sterigmata, slender, spreading and incurved, up to 9 μ long. *Spores* 5–7 μ in diameter, globose, 1-guttulate, the wall amyloid and finely echinulate with minute spines which are dissolved by treatment with potash solution. *Gloeocystidia* narrow, cylindrical, often flexuous, with obtuse apex, thin-walled, 50–80(–100) × 3–6 μ, the contents highly refractive, guttulate or broken up when old. (Fig. 7 *a–c*.)

On a fallen stick, Broadwater Forest, Sussex, A. A. Pearson, December 1923; on pine bark, Staverton, Devon, October 1924; on rotten pine bark, Broadwater Forest, Sussex, A. A. Pearson, December 1923.

Characterized by the globose, echinulate spores, which are stained blue by iodine, by the somewhat urniform shape of the basidia, which have however not more than four sterigmata, and by the long, slender gloeocystidia. The epithet *furfuraceum* cannot be used in *Corticium* because of the existence of the earlier *C. furfuraceum* Bres. (1925.)

Corticium (**Gloeocystidium**) **lentum** Wakef., nom.nov.

Gloeocystidium ochroleucum Bres. & Torrend in *Broteria* (ser. Bot.), **11**, 81, 1913; non *Corticium ochroleucum* Bres. nec *C. ochroleucum* Fr.

Irregularly effused, starting as numerous small patches which become confluent, when moist Warm Buff, with a rather definite white margin; when dry the colour darkens in patches to about Cinnamon Buff. *Hyphae* fine, 2–3 μ in diameter, thick-walled, flexuous, and very closely interwoven, so that the texture of the fungus is very tough and it is difficult to make a good crushed mount for microscopic examination. *Basidia* clavate, up to 10 μ wide above, with two to four straight sterigmata 5–6 μ long. *Spores* broadly ellipsoid or oblong, depressed on the inner side and rounded on the outer, with a short lateral apiculus, usually containing one large oil-drop, 10–12 × 5–6 μ. *Gloeocystidia* cylindrical or very slightly fusiform, flexuous, narrowed towards the apex, of varying length, 60–100 μ or more long, many extending from the basal tissues up to the surface of the hymenium, but not projecting, width 7–10 μ. (Fig. 11 *a, b*.)

On rotten decorticated wood, Henley wood, Sussex, A. A. Pearson, December 1938.

As with the previous species the change of name is necessary on trans-erence to the genus *Corticium* because of the existence of earlier homonyms. he structure of this fungus, with its closely woven fine hyphae, recalls hat of species of *Vararia*. There are, however, no true dichophyses in the ymenium. The large, oblong spores are distinctive.

Our fungus agrees with an authentic specimen from Bresadola (probably portion of the type) in the Kew Herbarium. Should it be proved ventually that *Corticium abeuns* Burt is the same species, as suggested by ogers and Jackson after examination of the type cited by Burt, then urt's epithet would have precedence in *Corticium*.

orticium (**Gloeocystidium**) **leucoxanthum** Bres. in *Fungi Trid.* **2**, 57 (tab. 166, fig. 3), 1898.

Effused, rather thick and waxy, smooth, firm when dry and closely dherent, dirty yellowish in colour (approximately Cream Buff to hamois), with no distinct margin. *Hymenium* compact, smooth. *Hyphae* losely interwoven and difficult to make out. *Basidia* clavate, not seen istinctly in this specimen but according to Bourdot & Galzin 30–60 × 6–9 μ, vith two to four sterigmata 6–11 × 2 μ. *Spores* large, cylindric-ellipsoid or blong, slightly curved in side view, amyloid, 13–16 × 4–7 μ. *Gloeocystidia* umerous, conspicuous, irregular and flexuous, arising from the base of he fructification and traversing the flesh up the surface of the hymenium, ot projecting, up to 130 μ long and 8–10 μ wide, subcylindrical or sub-usiform, the apex blunt or pointed, contents yellowish, granular or uttulate. (Fig. 17 *a–b*.)

On a twig, probably of *Corylus*, growing beneath the bark with the habit f *Corticium comedens*, near Box Hill, Surrey, P. H. B. Talbot, February 1946.

Easily recognized by the habit and by the large, curved, amyloid spores.

orticium (**Gloeocystidium**) **pallidum** Bres., *Fungi Trid.* **2**, 59 (tab. 168, fig. 1), 1898.

Gloeocystidium argillaceum sensu v. Höhn. & Litsch., nec *Corticium argillaceum* Bres., *Fungi Trid.* **2**, 63, 1898.

Irregularly effused, thin, when fresh rather waxy and continuous, ollowing the inequalities of the matrix, dirty white or pallid (Pinkish Buff r Cream Buff), becoming finely cracked on drying. When observed by eflected light with a strong lens the surface shows minute reddish or rownish dots, which become more distinct in the dried specimen. These ots are more or less rounded masses of resinous matter, up to 12 or 5 μ in diameter, which are formed at the ends of hyphae and are usually ore or less embedded in the tissues. *Hyphae* indistinct, 2·5–3 μ. *Basidia* lavate, 20–25 × 6–7 μ, with four sterigmata. *Spores* hyaline, allantoid, –11 × 2–3·5 μ. Occasional *gloeocystidia* present in the hymenium, subulate r narrowly fusoid, pale yellowish or hyaline, pointed at the apex, 0–60 × 5·5–7 μ. (Fig. 6 *a–c*.)

On bark or on rotten decorticated wood, both coniferous and frondose. Haslemere, September 1913; Weybridge, Surrey, A. A. Pearson, ovember 1919; Dipton Woods, Corbridge, Northumberland, September

1933; Mulgrave Woods, Sandsend, Yorkshire, September 1946; on Scotch Fir, Findogask, near Perth, S. Batko, April 1948; on very rotten beech wood, Quarry Ghyll, Masham, Yorkshire, W. G. Bramley, April 1950.

This fungus is often recognizable at sight because of the punctate appearance under the lens. Microscopic examination confirms the presence of the resinous masses, and the rather large allantoid spores are characteristic.

Peniophora affinis Burt in *Ann. Mo. bot. Gdn*, **12**, 266, 1925.

Broadly effused, membranaceous, more or less separable, when dry varying in colour from Light Buff or Pinkish Buff to Pinkish Cinnamon, the margin paler, and radiately fibrillose. *Hymenium* smooth, compact, often cracked when dry and showing the whitish subiculum beneath. *Hyphae* hyaline, septate, with very few or no clamp-connexions, the basal hyphae sometimes yellowish, rather thick-walled, flexuous, rather irregular and often swollen at the septa, 4–7 μ in diameter; subhymenial hyphae thinner-walled, much branched, 3–4 μ in diameter. *Basidia* clavate, 6 μ wide above, rather abruptly narrowed below, about 20–25 μ long, with four sterigmata about 5 μ long. Spores oblong-ellipsoid 5–5·5 × 2–2·5 μ, hyaline. *Cystidia* subfusiform, fairly thick-walled and encrusted with mineral matter above, narrowed towards the apex, 40–50 × 4·5–7 μ. (Fig. 31 *a–c*.)

On bark, Wheatley Wood, near Doncaster, Yorkshire, September 1914; Richmond Park, Richmond, Surrey, P. H. B. Talbot, October 1946.

This species resembles *P. velutina* in macroscopic characters, but differs in the smaller and more pointed cystidia and in the smaller hyphae. As pointed out by Rogers and Jackson, *Farlowia*, **1**, 318, there is no good specific distinction between *P. affinis* and the fungus which Burt called '*P. laevis* (Fr.) Burt', a name which is untenable.

Peniophora argillacea (Bres.) Sacc. & Syd., *Syll. Fung.* **16**, 194, 1902.

Corticium (*Peniophora*) *argillacea* Bres., *Fungi Trid.* **2**, 63, 1892, non *Gloeocystidium argillaceum* v. Höhn. & Litsch.

P. carneola (Bres.) v. Höhn. & Litsch. in *Wiesner Festschrift*, 1908, p. 70.

Indefinitely effused, soft and rather fleshy, when fresh at first white, becoming dirty Pinkish-Buff or alutaceous, stained here and there with brown, when dry approximately Light Drab to pale buff, often appearing finely porous under the lens; margin indeterminate. *Basal hyphae* septate, with clamp-connexions, branched, 4–4·5 μ in diameter, not very distinct. *Basidia* narrowly clavate, sometimes suburniform, 28–40 × 7–7·5 μ, with four sterigmata, finally often stained brown. *Spores* elliptical or ovate, depressed on the inner side, with a pronounced oblique apiculus, sometimes almost almond-shaped, 6–10(–12) × 4–6 μ, contents at first hyaline, but eventually becoming stained yellow-brown. *Cystidia* subulate, 40–110 μ long, 5–10 μ wide above, with a ventricose swelling up to about 16 μ at the base, contents yellowish brown, eventually exuded as an amorphous mass. In dried specimens the thin walls of the cystidia often collapse. (Fig. 29 *a–c*.)

On pine logs, Ashdown Forest, Sussex, A. A. Pearson, March and April 925; on rotten stick in mixed wood, Glengariff, Killarney, Eire, A. A. earson, September 1936; Muckross Demesne, Killarney, A. A. Pearson, eptember 1936; Arundel, Sussex, A. A. Pearson, May 1939; Stoner Hill, etersfield, Hampshire, A. A. Pearson, July 1939; on poplar bark, onhead St Mary, Wiltshire, T. W. Dunston, November 1939; Hindead, Surrey, A. A. Pearson, November 1940; Surlingham Wood, heatfen Broad, Norfolk, May 1946.

The type specimens of both *Corticium argillaceum* Bres. and *Kneiffia rneola* Bres. have been examined, and the difference between them appears be one of colour only. The type of *Corticium argillaceum* has remained lutaceous and the contents of the cystidia are more or less amberloured, whereas in *Kneiffia carneola* the secretion is more reddish and the lour of the fungus consequently varies from pinkish buff to Drab. The aracters of spores and cystidia are alike in both. For this reason they re here placed together, but there are other closely allied forms which em to be worth a distinct name. The following is one of these.

eniophora reticulata Wakef., sp.nov.

Irregulariter effusa, resupinata, tenuissima, adhaerens, albida, sub lente distincte oroso-reticulata et hispida, ambitu similari. Hyphae subhymeniales indistinctae; yphae basales sparsae, ramosae, flexuosae, irregulares, ad septa interdum leviter flatae, vix nodosae, 2–4 μ. Basidia suburniformia, 20–35–40 × 6–8 μ, 4 sterigmatibus ectis, vix curvulis, 5 μ longis. Sporae hyalinae, ovatae vel late ellipsoideae, basi tenuatae et oblique apiculatae (6–)8–10 × 4·5–5(–6·5) μ. Cystidia elongata, in basi ngi nascentia, et ad 150 μ emergentia, 170–250 μ longa, 10–12 μ crassa, basi saepe ad –25 μ inflata, apicem versus angustata, obtusa, tenuiter tunicata, laevia vel parte rominula sparse minute granuloso-incrustata, sicco saepe collapsa.

Ad lignam cariosam, praecipue coniferarum. Haslemere, Surrey, September 1913; rope Speldhurst, Kent, A. A. Pearson, December 1922 (type); Brown Clee Hill, urwarton, Shropshire, May 1932; Broadwater Forest, Sussex, A. A. Pearson, June 1932; enley Woods, Sussex, A. A. Pearson, December 1938; Hindhead, Surrey, A. A. Pearson, ecember 1940.

Irregularly effused, very thin, closely adherent, whitish, with no distinct argin, under a lens appearing porose-reticulate when dry, and hispid wing to the long, projecting cystidia. Subhymenial hyphae indistinct; asal hyphae scanty, branched, flexuous, irregular, sometimes slightly wollen at the septa, with only occasional clamp-connexions, 2–4 μ diameter. *Basidia* somewhat urniform, 20–35–40 × 6–8 μ, with four ather straight sterigmata, 5 μ long. *Spores* hyaline, ovate or broadly llipsoid, attenuated at the base and with an oblique apiculus, –) 8–10 × 4·5–5 (–6·5) μ. *Cystidia* very long, arising from the base of the orophore and projecting up to 150 μ, 170–250 μ long, 10–12 μ wide bove, often swollen at the base up to 20–25 μ, narrowed towards the btuse apex, thin-walled, smooth, or with the projecting portion encrusted ith minute granules, the wall often collapsed when dry. (Fig. 28 *a–c*.)

On rotten wood, chiefly coniferous.

This fungus is obviously closely related to *P. argillacea*, and was at first cluded with collections of that species. The specimens cited, however, gree with one another and seem distinct from *P. argillacea* in the very long cystidia, which give the hymenium a distinctly bristly appearance when it is viewed with a lens, and in the absence of any brown or reddish excretions. The reticulate habit is more evident, with a larger mesh, than in typical *P. argillacea*, and this seems to be a useful 'spot' character, hence the specific epithet.

Peniophora chordalis v. Höhn. & Litsch. in *S.B. Akad. Wiss. Wien*, **115**, 1598, 1906.

Effused, very thin, soft and waxy or almost mucilaginous in texture, becoming horny when dry, grey to livid in colour; margin not distinct, but here and there, especially towards the margin, there are very slender branched cords, visible only under the lens. The hymenium extends over these cords. *Hyphae* slender, about 2 μ in diameter, very closely agglutinated and difficult to distinguish. *Basidia* not seen in this specimen, but according to the authors 6–8 μ in diameter, clavate, with four sterigmata. *Spores* oblong-elliptical depressed on the inner side, smooth, hyaline, at first with guttules, 5–7 × 2·5–3·5 μ. *Cystidia* cylindrical, often slightly enlarged at the base, thin-walled, smooth, hyaline, projecting for most of their length, 65–70 × 6–8 μ (up to 10 μ at the base). (Fig. 34 *a*, *b*.)

On rotten decorticated wood, Arundel, Sussex, A. A. Pearson, May 1939.

A very inconspicuous fungus belonging to the section called by Bourdot and Galzin *Gloeocystidiales* because of the smooth, thin-walled cystidia, resembling gloeocystidia. The distinction made by these authors from the section *Gloeocystidium* of *Corticium* is that the cystidia do not originate deeply in the tissues and project above the hymenial surface for most of their length. It is not a very natural distinction and not always clear-cut, but regrouping of species must await further knowledge.

Peniophora crassa Burt ex Peck, *N.Y. St. Mus. Rep.* **54**, 155, 1901.

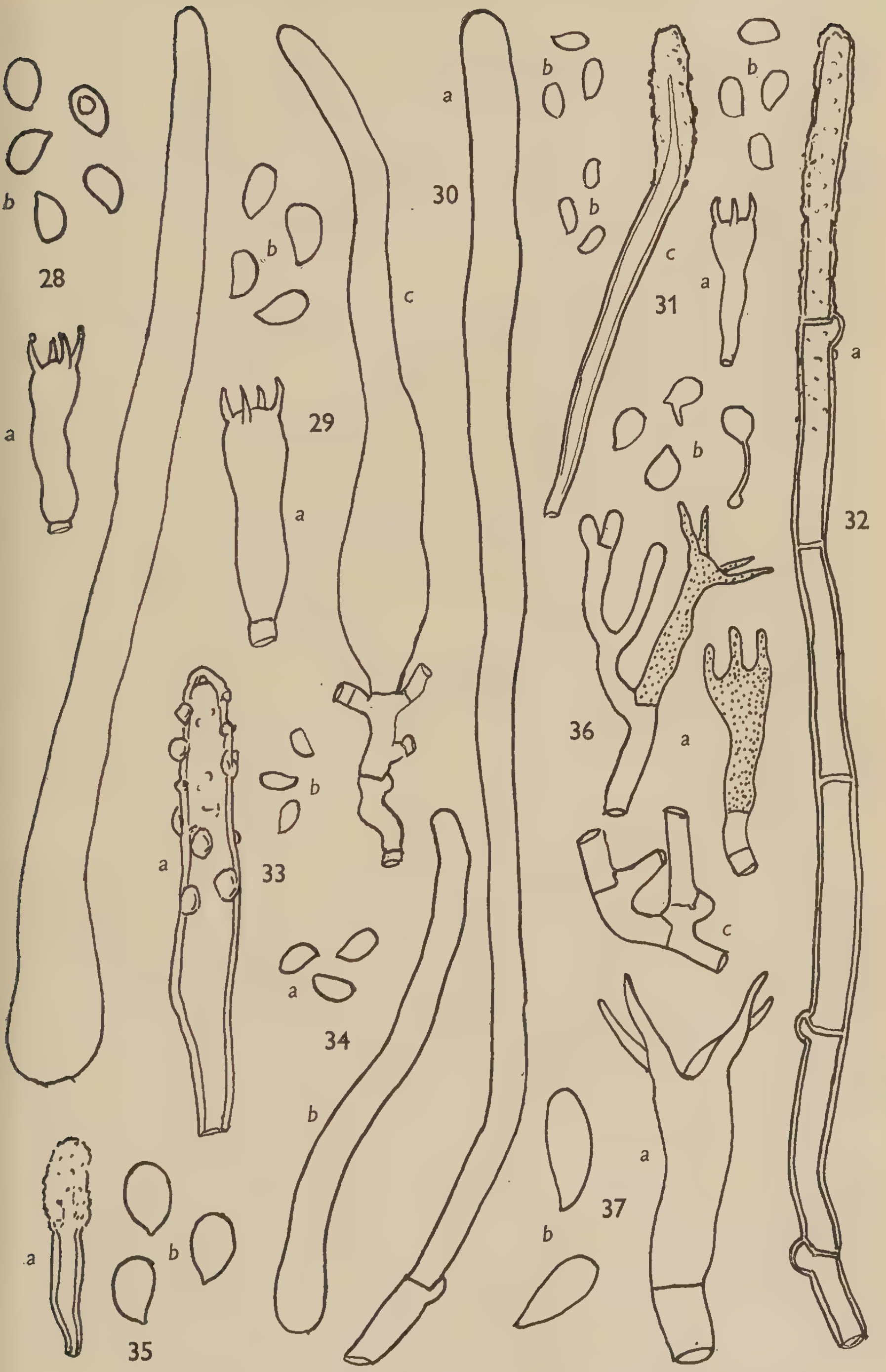
Stereum Karstenii Bres., in *I. R. Accad. Agiati Atti*, III, 3, 108, 1897, nec *Peniophora Karstenii* Massee in *J. linn. Soc.* **25**, 153, 1889.

This uncommon species was first recorded for this country in the *Naturalist*, 1923, p. 92, under the name *Stereum Karstenii* Bres., from specimens sent from Buckden, Yorkshire, by the late Mr W. N. Cheesman. It has since been found several times. Mr Pearson found it in the same woods at Buckden in October 1936, and again at Henley Common, Sussex, in December 1938. Other specimens have been received from Masham, Yorkshire, W. G. Bramley, October 1947, and near Perth, Scotland, S. Batko, January 1948.

The name *S. Karstenii* was proposed by Bresadola because a specimen

Legends to Figs. 28–37

Fig. 28. *Peniophora reticulata*. *a*, basidium; *b*, spores; *c*, cystidium.
Fig. 29. *P. argillacea*. *a*, basidium; *b*, spores; *c*, cystidium.
Fig. 30. *P. mollis*. *a*, cystidium; *b*, spores.
Fig. 31. *P. affinis*. *a*, basidium; *b*, spores; *c*, cystidium.
Fig. 32. *P. polonensis*. *a*, cystidium; *b*, spores.
Fig. 33. *P. filamentosa*. *a*, cystidium; *b*, spores.
Fig. 34. *P. chordalis*. *a*, spores; *b*, cystidium.
Fig. 35. *P. proxima*. *a*, cystidium; *b*, spores.
Fig. 36. *Ceratobasidium atratum*. *a*, basidia; *b*, spores.
Fig. 37. *C. terrigenum*. *a*, basidium; *b*, two spores.



Figs. 28–37. (All figures, × 800.)

of this fungus was issued by Karsten in his Fungi Fennici Exsiccati No. 959 under the name *S. odoratum* (Fr.) Fr., which is however another plant. The present species is a very distinct plant, marked by its conspicuous projecting cylindrical cystidia, the walls of which are dissolved by potash solution. In this respect it resembles *Peniophora glebulosa*, and Rogers and Jackson, *Farlowia*, **1**, 326, 1943, consider it to be better placed in *Peniophora* than in *Stereum*. When transferred to *Peniophora* the epithet *Karstenii* cannot be used because of the earlier *P. Karstenii* Massee, but fortunately there is another name available, namely *P. crassa* Burt. A fuller description is appended:

Entirely resupinate, at first somewhat fleshy and forming small, thick, cushion-like patches which later become confluent and form a wide-spreading, slightly separable, thick, tough sheet. *Hymenium* alutaceous or with a slight pinkish buff tinge, pruinose or velutinate under a lens, cracking when dry: margin white, fimbriate. The tissue in section shows two distinct layers, a basal layer of loosely woven hyphae, 4–5 μ, with very thick walls and narrow lumen, and an upper layer of erect, parallel hyphae 2–2·5 μ, through which the long cystidia pass and project above the hymenial surface. *Cystidia* arising from the basal tissue and projecting up to 25 μ, very long, smooth, hyaline, cylindrical, 4–5 (–7) μ wide, blunt, thick-walled below, thin-walled at the apex, very brittle and easily broken when dry, walls soluble in alkaline solutions. *Basidia* crowded, 2–3 (–4) μ wide, with two to four sterigmata. Spores allantoid, hyaline, 5–6 × 1–1·5 μ.

Readily recognizable by the spores and by the peculiar long cystidia. The mycelium when fresh is sometimes fragrant (smell of anise). As with *P. glebulosa* it is advisable to use lactic acid or lactophenol rather than alkali when making microscopic mounts from dried material of this species.

Peniophora filamentosa (B. & C.) Burt in Coker, *J. Elisha Mitchell sci. Soc.* **36**, 162, 1921.

Widely effused, membranaceous, forming an easily separable sheet with pubescent rhizomorphic strands spreading outwards from the margin. *Hymenium* smooth, compact, pinkish grey in colour (about Tilleul Buff), subiculum and margin Ochraceous Buff. *Hyphae* hyaline but heavily encrusted with yellowish granules which are dissolved by alkaline solutions with the production of a crimson colour, irregular, 4–6 μ in diameter, often inflated to 7–8 μ near the septa, clamp-connexions rare or absent. *Basidia* hyaline, clavate, 16–30 × 4·5–6 μ. *Spores* hyaline or slightly yellowish, ovate, but slightly flattened on the inner side and attenuated obliquely at the base, 4·5–5 × 2–2·5 μ. *Cystidia* rather thick-walled, encrusted above with crystals, the incrustation becoming detached in crushed mounts and dissolving more or less when treated with potash solution; shape of cystidia fusiform or cylindrical, narrowed at the apex and attenuated below into a narrow stalk, 40–80 × 8–12 μ. (Fig. 33 *a*, *b*.)

On bark, Cawthorne, Yorkshire, A. A. Pearson, September 1941.

A beautiful species, of wide distribution in both temperate and tropical regions. It is easily distinguished by the yellow-brown cords, contrasting with the somewhat greyish hymenium, by the texture, the crimson colour when treated with potash, and by the microscopic characters.

eniophora mollis (Fr.) Bourd. & Galz. in *Bull. Soc. mycol. Fr.* **28**, 389, 1912.

Indefinitely effused, forming a thin, easily separable pellicle. *Hymenium* hen fresh cream to alutaceous or even pale egg-yellow, with here and iere a tinge of flesh-colour, somewhat waxy and wrinkled, under the lens ough with occasional minute granules and hair-like cystidia, when dry nooth, cracked, and in colour Light Ochraceous Salmon or Pinkish Buff pale Buffy Brown, the margin white, byssoid. *Subiculum* loose, byssoid, sible in the interstices of the cracked hymenium when the fungus is dry. *asal hyphae* loosely interwoven, septate, with large, often annular amp-connexions, branched, 4–6 (–7·5) μ in diameter. *Basidia* clavate, 5–20 × 4 μ, with two to four sterigmata. *Spores* ellipsoid or oblong, with minute apiculus, thick-walled, hyaline or slightly tinged yellowish, –7 × 3–4 μ. *Cystidia* rare, very long, cylindrical or slightly clavate, adually narrowed downwards into the hyphae, with a clamp-connexion the dividing wall, obtuse at the apex, 100–150 × 7–9 μ, hyaline. ig. 30 *a*, *b*.)

On pine bark, Weybridge, A. A. Pearson, February 1920; on bark, ast Horsley, Surrey, A. A. Pearson, April 1922; on a plank buried in il, Eridge Park, Sussex, A. A. Pearson, November 1922; on pine wood, peldhurst, Kent, A. A. Pearson, December 1922; on very rotten coni-rous wood, Kent, A. A. Pearson, October 1924; Tilgate Forest, Sussex, Iay 1931; St Leonard's Forest, Sussex, A. A. Pearson, 1 June 1931.

Distinguished by the pinkish-buff pellicular hymenium, the long, attered cylindrical cystidia, and the comparatively thick-walled spores.

eniophora polonensis (Bres.) v. Höhn. & Litsch. in *Ann. mycol., Berl.*, **4**, 292, 1906.

Kneiffia polonensis Bres. in *Ann. mycol., Berl.*, **1**, 103, 1903.
Peniophora canadensis Burt in *Ann. Mo. bot. Gdn*, **12**, 260, 1926.

Effused, very thin, at first loose and 'hypochnoid', white to cream-loured, later more membranaceous and forming a separable pellicle, ut never waxy, when dry alutaceous (Pale to Light Ochraceous Buff), hen looked at with a lens bristling with the abundant, long, projecting stidia. *Basal hyphae* loosely woven, hyaline, with clamp-connexions, –6 μ in diameter, not very distinct. *Basidia* clavate, 20–25 × 5 μ, with ur sterigmata. *Spores* oblong-elliptic, hyaline, smooth, 6–7·5 × 4–4·5 μ. *ystidia* very numerous and very long, up to 260 μ, arising from the basal yphae and projecting up to 100 μ beyond the surface of the hymenium, yaline to ochraceous, cylindrical, thin-walled and rounded above, thick-alled below, septate, with clamp-connexions at the septa, 8–10 μ wide; e projecting portion is strongly encrusted with crystals which disappear mounts made with dilute potash solution. (Fig. 32 *a*, *b*.)

On bark of beech, Michel Grove, near Littlehampton, Sussex, October 928; on rotten wood, Rewell Wood, Arundel, Sussex, October 1928; laise Castle Woods, Bristol, October 1929; on *Salix* bark, Duckhole, hornbury, Gloucestershire, R. W. G. Dennis, May 1950.

This species has septate cystidia like those of *P. setigera*, but more slender. differs from *P. setigera* and *P. odontioides* Burt, which also has similar cystidia, in the shorter spores. It is a delicate, white, pellicular species, and does not belong in the section Ceraceae where it was placed by Bourdot and Galzin. The British specimens have been compared with type material from the herbarium of Bresadola.

Peniophora proxima Bres. apud Bourd. & Galz. in *Bull. Soc. mycol. Fr.* **28**, 402, 1912.

Effused in rounded or oval patches, waxy, rather thick, very closely adherent and somewhat horny when dry. *Hymenium* pulverulent under a lens, Pinkish Buff to Light Pinkish Cinnamon, waxy, cracked when dry; margin paler and somewhat fimbriate, but distinct, sometimes becoming slightly free. Basal tissue rather thick, compact. *Hyphae* closely interwoven, hyaline to yellowish, with occasional clamp-connexions, not always very distinct, 3·5–5 μ in diameter. *Basidia* clavate, about 30–40 × 7–8 μ, with short sterigmata. *Spores* broadly oblong, slightly flattened on the inner side, smooth, scarcely apiculate, 10–12·5 (–13) × 6·5–7·5 μ. *Cystidia* arising at various levels in the trama, variable in length, 30–55 × 5–6 (–9) μ, thick-walled, yellowish, more or less fusiform but often flexuous and irregular, the upper part encrusted with crystals. (Fig. 35 *a*, *b*.)

On *Buxus*, Mickleham, Surrey, J. Harvey Bloom, January 1923; on *Buxus*, Box Hill, Surrey, R. E. D. Baker, September 1946, and S. J. Hughes, January 1947.

This species appears to be peculiar to Box, as already noted by J. Eriksson in Sweden. It is somewhat like *P. incarnata* in colouring, but differs in the larger spores. Some specimens show scarcely any encrusted cystidia.

Cyphella albocarnea Quél. in *Bull. Soc. bot. Fr.* **25**, 290, 1878.

Fructifications cupular, sessile, minute, *c.* 0·25–0·5 mm. in diameter, externally pure white, villose, hymenium Pinkish-Buff. External hairs encrusted with mineral matter, which is easily detached when a crushed mount is made, leaving a long, pointed, flexuous, whip-like hair, 2–3 μ in diameter. *Basidia* clavate, *c.* 15 × 6 μ. *Spores* hyaline, smooth, elliptical with a lateral apiculus, contents somewhat cloudy, 7–9 × 3–4·5 μ.

On dead stems of *Galium aparine*, Thornbury, Gloucestershire, R. W. G. Dennis, November 1948.

The specimens agree very well with the description of *Cyphella albocarnea* and with the figure given by Boudier (*Icon. Mycol.* **1**, pl. 172). No specimens are available for comparison. *C. cyclas* Phill. was also described as having a pinkish hymenium, but the spores of that species are said to be narrowly oblong and curved, so that it can hardly be the same.

Cyphella citrispora Pilát in *Ann. mycol., Berl.*, **22**, 209, 1924.

Fructifications at first globose, then cupular or flattened with incurved margin, about 200–600 μ in diameter, whitish or cream-coloured, membranaceous, externally clothed with long, somewhat wavy, granule-encrusted hairs, 2·5 μ thick. *Hymenium* white or cream, concave, smooth. *Basidia* cylindric-clavate, 20–25 × 8–12 μ, with four slender sterigmata, 2–6 μ long.

bores fusiform, sharply narrowed at each end, acute or obtuse, hyaline, nooth, with one or more guttules, 13–16 × (4·5–) 6–7 μ.

On dead sheaths of *Cladium mariscus*, Home Marsh, Wheatfen Broad, orfolk, M. B. Ellis, May 1947.

The specimen here cited was named by Dr P. H. B. Talbot, of Pretoria, ho was at that time working at Kew. He also determined as the same pecies a specimen on oak bark from Elland Park Wood, near Halifax, ollected in July 1892 and preserved in the Crossland herbarium under e name '*Dasyscypha leuconica* (Cooke) Massee'. The spores of the Wheat-n collection are longer than those described by Pilát for the type, and in is respect agree rather with the spores of Pilát's variety *Crataegi*, which ere given as 9–13 × 6–7 μ. This species seems to favour such substrata as *lnus*, *Cladium*, etc., which are found in damp or marshy places.

ellicularia pruinata (Bres.) Rogers ex Linder in *Lloydia*, **5**, 170, 1942.

Corticium pruinatum Bres. in *Ann. mycol., Berl.*, **1**, 99, 1903.
C. coronatum sensu v. Höhn. & Litsch. in *Ann. mycol., Berl.*, **4**, 291, 1906.

Effused, very thin and mould-like, under the lens arachnoid, the ymenium at first loose and somewhat tufted, later nearly continuous, parable when dry, whitish to deep cream-coloured or buff, sometimes ith a greyish tinge. *Hyphae* branched, septate, without clamp-conexions, the basal hyphae often rather thick-walled and yellowish, –15 (–20) μ in diameter, the subhymenial hyaline, 5–10 μ, branching in cymose manner. *Basidia* short, subcylindrical, 12–15 × 6–9 μ with four six sterigmata up to 5 or 6 μ long. *Spores* hyaline or faintly tinged ellowish, subglobose or broadly ellipsoid, attenuated below to a lateral piculus, obtuse at the apex, 4–7·5 × 3–4 (–5) μ. (Fig. 27 *a–c*.)

On wood and bark of various trees, chiefly Dicotyledons. On beech, taverton, Devon, October 1924; Hulne Park, Alnwick, Northumberland, eptember 1933; Stratton Strawless, Norfolk, October 1934; Ross Island, illarney, Eire, A. A. Pearson, September 1936; Kinlet Park, near leobury Mortimer, Shropshire, September 1937; on dead bark of beech, ox Hill, Surrey, S. J. Hughes, September 1946; on ash, Arborfield, erkshire, September 1948.

This species resembles *Pellicularia vaga* very closely and is sometimes ifficult to distinguish. The chief obvious difference is in the spores, which *P. pruinata* are never boat-shaped but always obtuse at the apex and latively short. Also the basal hyphae in *P. pruinata* are as a rule thicker nd more coloured than in *P. vaga*. Rogers has shown that *Oidium ndicans* (Sacc.) Linder is the conidial form of this species, and the onnexion has been confirmed in a preparation made by Mr S. J. Hughes om the Box Hill specimen.

eratobasidium anceps (Bres. & Syd.) Jackson in *Canad. J. Res.* C, **27**, 243, 1949.

Corticium anceps (Bres. & Syd.) Gregor in *Ann. mycol., Berl.*, **30**, 464, 1932.

This interesting parasite of *Pteridium aquilinum*, described originally as *Tulasnella* and later placed in *Corticium* by Mrs Gregor because of its semblance to the section *Botryodea* of *Corticium* (now the genus *Pellicularia*), has recently been investigated in Canada by Prof. H. S. Jackson. As had been already noted in British specimens, the spores of this fungus germinate by repetition, and it seems therefore better placed in the genus *Ceratobasidium* Rogers, which was defined in 1935, and is a connecting link between *Pellicularia* and the Heterobasidiomycetes.

Ceratobasidium atratum (Bres.) Rogers ex Martin in *Lloydia*, **4**, 262, 1941.

Corticium atratum Bres. in *Hedwigia*, **35**, 290, 1896.

Effused in interrupted patches, with no distinct margin, waxy, rather thick and separable when fresh, dark grey or blackish, becoming paler grey when dry. *Hymenium* smooth, compact, pruinose under the lens. *Hyphae* hyaline or tinted fuscous, thin-walled, 2–5 (–6) μ in diameter, with clamp-connexions at least in the basal hyphae. *Basidia* irregular both in shape and size, clavate or cylindrical, 20–40 (–45) × 7–10 μ, when long often flexuous, usually very much narrowed towards the base, rarely slightly ampulliform, when young with granular contents coloured yellowish fuscous, empty and hyaline when old, with four long, curved sterigmata 10–15 μ long, 2–2·5 μ wide at the base, and with the apex either blunt or pointed. *Spores* hyaline or sometimes stained brownish in slide preparations, broadly ovate or pip-shaped, contracted below into a prominent apiculus, sometimes incurved towards the base, 7–9 × 4–5·5 μ, germinating by repetition. (Fig. 36 *a*, *b*.)

On rotten decorticated wood, Thirlmere, Cumberland, A. A. Pearson, September 1922; on rotten wood, Eridge Bottom, Sussex, A. A. Pearson, February 1925.

For a long time the identity of this fungus has been in doubt. While the general characters appear to agree with those of *Ceratobasidium atratum* the basidia in these specimens are much longer than those of the type specimen of *Corticium atratum* and also longer than those figured by G. W. Martin for *Ceratobasidium plumbeum* Martin, which D. P. Rogers cites as a synonym of *C. atratum*. In a specimen from New York named by Rogers, and recently received at Kew, the basidia are longer and more like those of the British specimens, though still not quite so *Hydra*-like in appearance as those of our material. The difference does not seem sufficient to warrant a new name. The spores and the dark colouring matter found in the basidia and sometimes staining also hyphae and spores, seem to be characteristic of the species.

Ceratobasidium terrigenum (Bres.) Wakef. comb.nov.

Corticium terrigenum Bres. in *Ann. mycol., Berl.*, **1**, 98, 1903.

Effused, greyish, becoming slightly tinged lilac-fawn in the older parts so that to the naked eye it suggests a species of *Tomentella*. *Hymenium* beginning apparently as small patches which become confluent, somewhat fleshy, continuous, granular in appearance because of the underlying sand; margin pale greyish white, pulverulent, not fimbriate. *Hyphae* hyaline, fairly thick-walled, branching at right-angles septate, frequently towards the hymenium, without clamp-connexions, 7–8 μ in diameter.

asidia hyaline, somewhat clavate, 20–30 × 10–12 μ; sterigmata (or epi-
asidia) four, 15–17 × 2·5 μ, flexuous, acute at the apex. *Spores* oblong or
ubfusiform, depressed on the inner side and sometimes slightly incurved
t the base, variable in size, 14–18 × 5–7·5 μ. (Fig. 37 *a*, *b*.)

On sandy ground, Virginia Water, Surrey, October 1931.

The spores resemble in form those of *Ceratobasidium sterigmaticum* (Bourd.)
ogers, but in that species the basidia are constantly two-spored. Com-
arison with the type specimen of *Corticium terrigenum* Bres. from the
erbarium of Bresadola at Stockholm leaves little doubt as to the identity
f the present fungus, although *C. terrigenum* was described as membra-
aceous and the spores were given as slightly smaller. The dried specimen
ow looks membranaceous, but the hymenium was certainly slightly
eshy when fresh. Spore germination has not been observed, but the
ecies is referred to *Ceratobasidium* on account of its general resemblance
other species of this genus.

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ACTINOSPORA MEGALOSPORA N.SP., AN AQUATIC HYPHOMYCETE

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(With Plate 1 and 4 Text-figures)

A description is given of *Actinospora megalospora* n.gen., n.sp., an aquatic Hyphomycete growing on submerged twigs. The fungus has a branched dichotomous conidiophore bearing very large conidia (terminal thallospores) that are typically tetra-radiate. Growth in pure culture is described. A comparison is made with other Hyphomycetes having tetra-radiate conidia.

Actinospora gen.nov.

Fungi mycelio ramoso septato. Conidium (thallospora terminalis) consistens in parte globosa vel subglobosa conidiophorae adnexa et 4 (vel pluribus) hyphis longis in speciem radiorum extentis.

Actinospora megalospora sp.nov.

Fungus aquaticus submersus mycelio repente hyalino, septato, ramoso. Conidiophora inferiore parte 100–300μ longa, 8–10μ lata, simplici et recta, superiore 3–4-ies aequaliter vel inaequaliter dichotoma, cuius cellula ultima inflata atque unum solum conidium ferens; e conidiophora 5–20 conidia simul oriuntur, pariter adolescunt. Conidium (thallospora terminalis) in parte globosa vel subglobosa (35–40μ dia.) consistit, protoplasma brunneum et spumosum contintente, unde 4–8 (sed plerumque 4) hyphae simplices, 100–180μ longae, 8μ latae, rectae, 1–3-ies septatae, protoplasmate hyalino plenae, in speciem radiorum eminent. Huius conidii pars globosa conidiophorae adnectitur, hyphae rectae simul nascuntur.

Hab. In ramulis emortuis *Crataegi* in flumine submersis, Sevenoaks, Kent, Anglia.

In previous papers (Ingold, 1942, 1943*a*, *b*, 1944) an account has been given of the Hyphomycetes that make up the characteristic flora of decaying leaves of deciduous trees in streams. In most species the conidia, produced, liberated and dispersed below water, are of a striking form, being either long and curved or, more usually, branched. Very often the conidium consists of four long straight arms diverging from a common centre. The peculiar conidia of these fungi were first encountered in the scum, often foamy, that gathers here and there behind twig-barriers on the surface of a stream, and it was only later that their source was discovered. The occurrence of these conidia in the scum is not due to their density being less than 1·0—indeed they are slightly denser than water—but to the fact that the scum acts as a trap catching any spores that happen to come in contact with it.

In December 1950 examination of scum from a stream near Sevenoaks, Kent, showed in addition to a rich collection of spores belonging to known species, a number of very large conidia of a remarkable type. (Text-fig. 1 and Pl. 1, A, B). Each consisted of a central subspherical part (35–50μ diameter) filled with foamy brown protoplasm. From this there radiated four to eight (usually four) long, straight, colourless arms

100–180 μ long, 8 μ wide and 1- to 4-septate, the whole span of the conidium often exceeding 350 μ so that individual conidia were easily visible through a hand-lens.

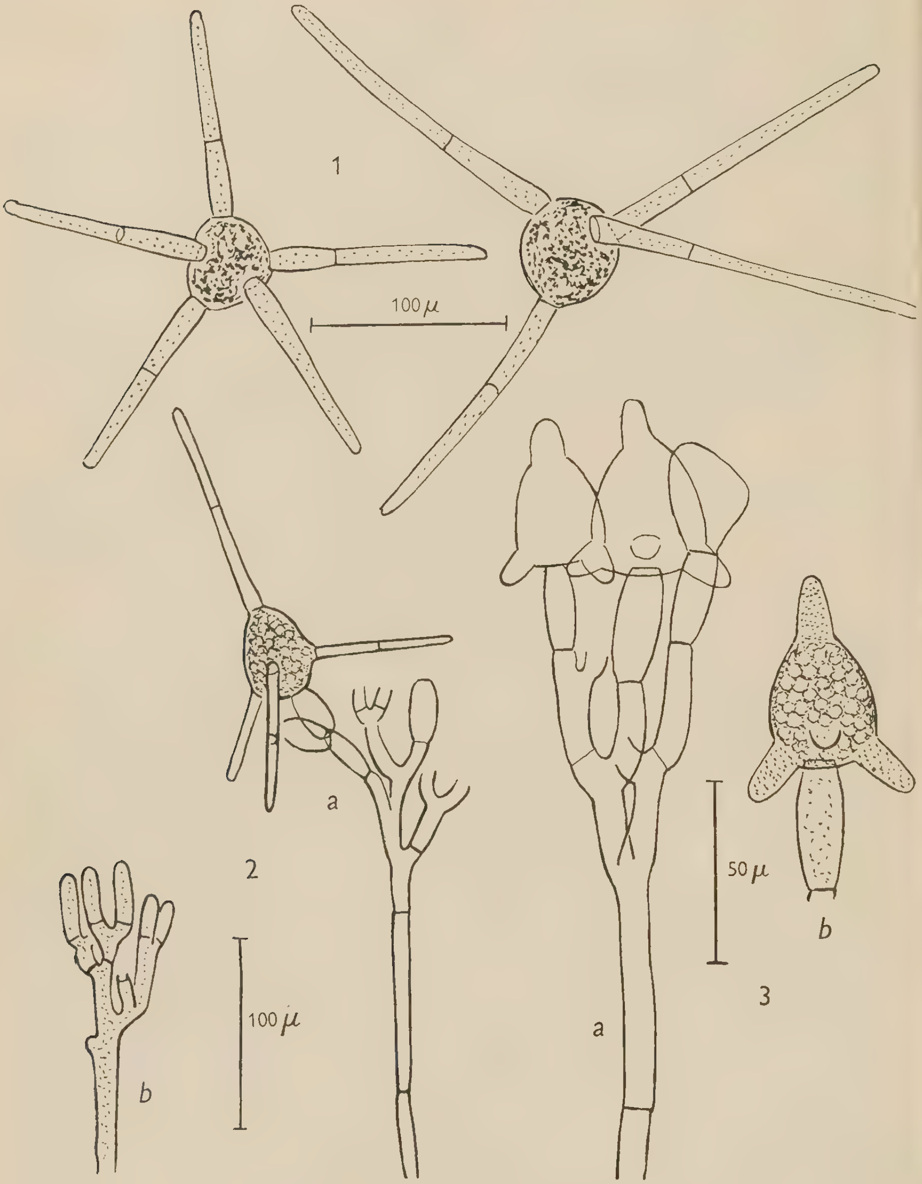
The scum in which the conidia occurred was teeming with bacteria, but it was found possible to remove individual conidia on fine glass needles, and by washing in several changes of sterile water and finally planting on nutrient agar, a number of pure cultures were obtained. On all media used (i.e. 2% malt agar, corn-meal agar enriched with peptone, and Difco 'beef-extract-peptone bacto-agar') growth was very similar. Although the rate of extension growth was considerable (0·5 cm. per day at 20° C.), the mycelium was rather sparse and no aerial hyphae were produced. In a Petri dish the colony was clearly visible only when light fell obliquely on the surface. The fungus grew down into the medium at the same rate as it grew over the surface. After 10 days' growth on beef-extract-peptone agar about 6 cm. deep in a deep Petri dish, a hemispherical colony with a radius of 5 cm. was produced. Evidently the fungus is a micro-aerobe. However, downward growth into agar does not continue indefinitely for when grown in unslanted test-tubes three-quarters filled with nutrient agar, downward growth ceased when the mycelium reached a depth of about 6 cm. The mycelium is branched, septate and colourless. In the sparseness of its growth, in the absence of any aerial hyphae and in the deep penetration of the medium this species is quite unlike the aquatic Hyphomycetes of decaying leaves, some twenty of which have been cultured.

In pure culture on nutrient agar no reproductive bodies were formed and attempts to induce sporulation, by submerging the mycelium in water and by growing the fungus on submerged sterilized twigs, failed.

After prolonged search on various substrata in the stream, the fungus was eventually found growing on a submerged decaying stick of hawthorn about the size of a pencil. The mycelium was apparently in the twig and the conidiophores projected at right angles from the bark into the water.

The conidiophore (Text-fig. 2) is a structure superficially like that of *Penicillium* with an unbranched stalk and an upper closely branched region, but unlike *Penicillium* branching is a true dichotomy and in this respect the closer comparison is with the conidiophore of *Peronospora*. The end cells of the conidiophore are rather swollen, almost ovoid structures each bearing a single conidium. This is a terminal thallospore which, at a very early stage in its development, is delimited by a cross-wall at its base. The number of conidia on a conidiophore varies from five to twenty, and a striking feature is that they are nearly always at the same stage of development on any one conidiophore.

The young conidium (Text-fig. 3) starts as a subspherical to tetrahedral cell. Then the arms (usually four) arise simultaneously as little bulges, and begin to grow out. It is soon evident that there is a striking difference in the protoplasm of the central part and of the arms. That of the central region has a foamy structure and later turns brown, but in the arms it is finely granular and never becomes coloured. By the time the arms of the conidium are about 30 μ long a wall is laid down separating each arm from the central part. Each increases by apical growth until it is 100–180 μ long



Text-figs. 1–3. *Actinospora megalospora.*

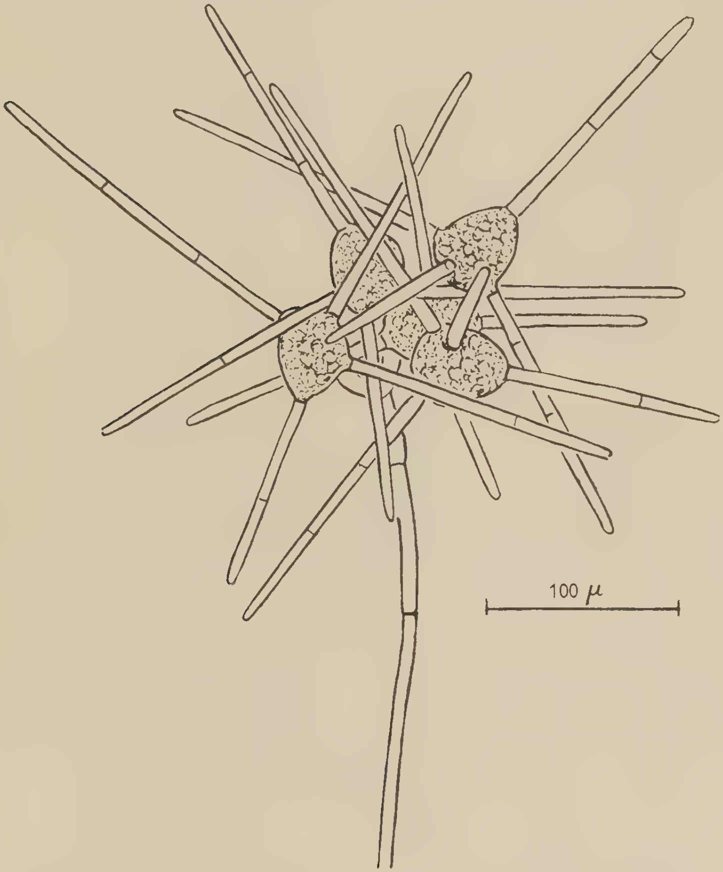
Text-fig. 1. Two conidia from scum. That on left has rather short arms. In the other they are of more usual length.

Text-fig. 2. *a*, conidiophore drawn from living material on the submerged twig. Only one conidium is shown and only a part of the branch system which is spread out somewhat to show the manner of branching. *b*, a young developing conidiophore.

Text-fig. 3. *a*, part of a small conidiophore. About eight developing conidia were present but only three are shown. *b*, the middle conidium (drawn about 15 min. later) showing the protoplasmic contents.

and by this time it has several septa. On staining with iodine the central region becomes reddish brown, presumably due to the presence of glycogen, but the arms are stained only a pale yellow. Each terminal cell of the conidiophore produces only one conidium.

The conidiophore with an apical cluster of five to twenty mature conidia presents a striking appearance. It is, however, a very difficult object to draw. That shown in Text-fig. 4 bears five conidia, but the branch system of the conidiophore is almost obscured by the mature conidia. Judging from their appearance on the conidiophore it might be expected that the spores would stick together and be dispersed in a clump. However, this is clearly not so, for although hundreds of conidia have been examined from the stream scum, they have always occurred singly.



Text-fig. 4. *Actinospora megalospora.* Conidiophore with five mature conidia.

The conidia germinate readily in a nutrient solution by a germ tube from the tip of each arm, but never from the central region.

In the majority of submerged aquatic Hyphomycetes with tetra-radiate conidia, the conidium is attached to its conidiophore by the tip of one of its arms (e.g. in the genera: *Articulospora*, *Tetracladium*, *Tetrachaetum*, *Alatospora*, *Clavariopsis*), but in *Lemonniera* and *Triscelophorus* attachment to the conidiophore is near the point of divergence of the four arms. In this respect *Actinospora megalospora* agrees with these two genera. Superficially there is a rather striking agreement with *Lemonniera aquatica*. In both the conidiophore is a structure with a lower straight part and an upper branched region bearing a number of conidia, and in both the arms of the conidium develop simultaneously. But there are striking differences that altogether preclude the placing of the two species in the same genus. In *Actinospora megalospora* the conidium is a thallospore, not a phialospore as in *Lemonniera*; further, the branching of the coniophore differs from that of *Lemonniera* in being truly dichotomous. Except for the facts that attachment of the conidium is near the point of divergence of the four arms and that the spore is a terminal thallospore, there is no similarity to *Triscelophorous monosporus* in which the spore occurs singly at the end of an unbranched conidiophore and the four arms arise in succession.

The type specimen is deposited in the Herbarium of the Commonwealth Mycological Institute, Kew, No. 47684.

My best thanks are due to Mr D. Jones for his help with the Latin diagnosis.

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EXPLANATION OF PLATE 1

Actinospora megalospora. Two conidia from the stream scum. B is a five-armed conidium which is beginning to germinate, and a short germ tube 5–10 μ long is developing from the tip of each arm.

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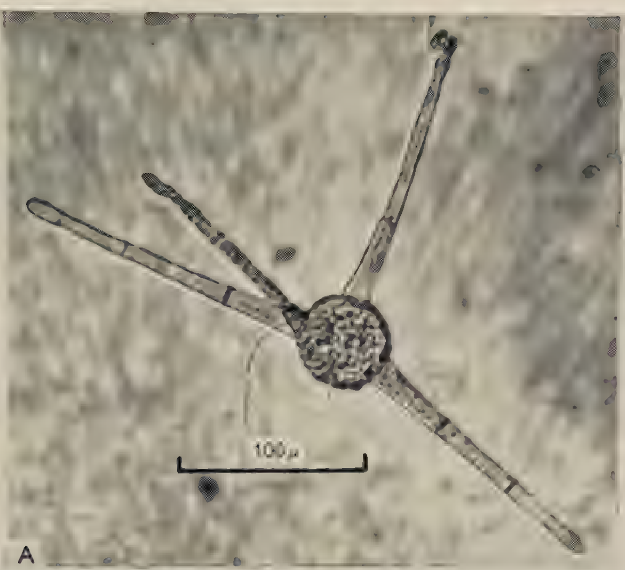
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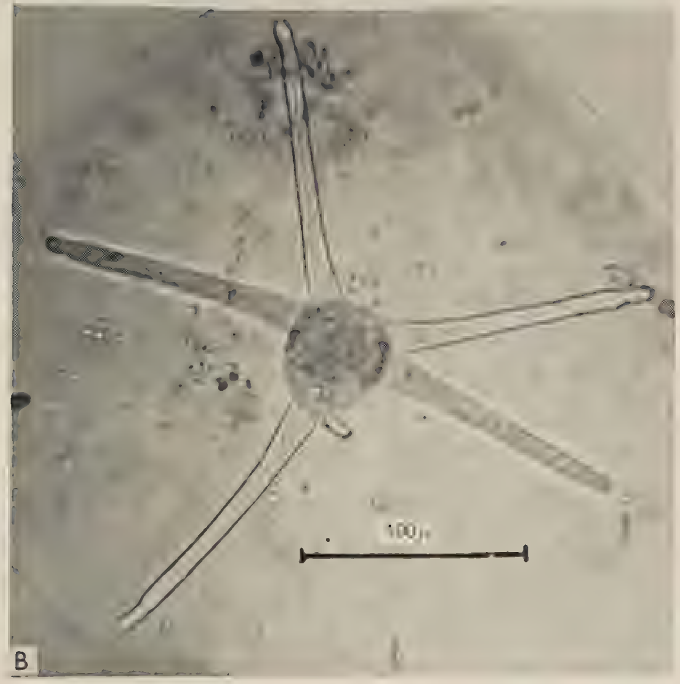
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B

VARIETAL RESISTANCE AND SUSCEPTIBILITY OF OATS TO POWDERY MILDEW (*ERYSIPHE GRAMINIS*)

By E. T. JONES and D. J. GRIFFITHS

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A study of the varietal reactions of oat varieties to powdery mildew (*Erysiphe graminis* DC.) has revealed that there is no lack of mildew-resistant breeding material in the genus *Avena*. Most of the varieties tested were highly susceptible to attack; others, though not immune, showed a high degree of resistance at certain phases of plant growth. The two diploid varieties *A. strigosa* ssp. *hirtula* and *A. strigosa* var. *glabrota*, and the hexaploid Cc 4146 exhibited a high degree of resistance in the seedling and adult stages.

Preliminary studies on the inheritance of reaction to *Erysiphe graminis avenae* have shown that, in two crosses studied, resistance and susceptibility appeared to be dependent on a single factor pair. With the identification of these new factors for resistance to mildew a really effective approach towards the control can be made by breeding.

As considerable variations in the stability of reaction to infection were observed in the different hosts, some showing more or less uniformity of resistance and others showing considerable fluctuation, it appears that resistance to *Erysiphe graminis avenae* could, with advantage, be studied also in relation to the possible existence of physiologic races.

Powdery mildew is one of the commonest diseases of cereal crops in Britain. It is present to a certain extent in most crops of wheat, barley, oats and rye, but the severity of the attacks varies from district to district and from season to season. On oats the disease is most destructive in the cooler, more humid western districts, in seasons when mild winters are followed by dry weather in spring and early summer. Particularly heavy epidemics have been observed to occur in late-sown spring crops grown alongside mildewed winter oats. Such an attack was experienced in May 1950 in the cereal nursery at the Welsh Plant Breeding Station.

Appearance of the disease

The powdery mildew fungus (*Erysiphe graminis* DC.) is an external parasite which is first in evidence as superficial groups of a flocculent growth on the upper surfaces of the leaves and leaf sheaths, beginning on the lower leaves and spreading to the upper if conditions continue to be favourable. The fungus may appear first as isolated colonies or patches, white when young, becoming powdery with the production of conidia and changing to grey or brown with age. On extremely susceptible varieties the colonies may be so numerous as to coalesce and form extended areas completely covered by the fungus. When conditions favour rapid reproduction, conidia are produced in great profusion, and these contribute to a rapid spread of the disease. New crops of spores are produced 10–14 days after each separate infection occurs, and this build up of infective material continues until the host tissue dies. The fungus thus exhibits a cycle of spore production, dissemination and re-infection in close sequence, which usually coincides with the vegetative development of the host. As the crop matures the superficial mycelium darkens, and under favourable conditions perithecia develop in the mycelial mats. The studies of Graf-Marin (1934) and others have demonstrated that ascospores of *E. graminis* are equally as infective as conidia. The evidence suggests, however, that ascospores are liberated mainly in the autumn, and that the main source of infection in spring appears to be the conidia produced from the mycelial infection formed on overwintering hosts (Cherewick, 1944; Moore, 1945).

Grainger (1947) has recently reported on the relative importance of temperature and humidity in the development and spread of the disease in the oat crop. On the basis of meteorological data collected in the west of Scotland, he suggested that the severity of the disease in the field increases with the rise in saturation of the atmosphere. Grainger's results also indicate that application of both nitrogen and potash tends to increase the severity of attack, while phosphate increases resistance to infection. Most workers have reported increasing susceptibility to mildew in wheat and barley when nitrogenous fertilizers are applied, but the results obtained with other chemicals and fertilizers are not all in complete accord. Cherewick (1944), however, found that the addition to the soil of certain fertilizers and other chemicals previously claimed to increase host resistance in these two cereals did not increase the resistance of susceptible seedlings. Smith and Blair (1950) claimed that the application of lithium chloride to the soil successfully reduced mildew infection on wheat seedlings grown under glasshouse conditions, but under field conditions the treatment proved much less effective.

Host specialization and varietal reaction

Since the discovery of pathogenic specialization in *E. graminis* by Marchal (1902, 1903) many authors have contributed to our knowledge of the subject. Marchal established the existence of specialized varieties of the fungus on the basis of restriction of infection to certain host species: *tritici* on wheat, *hordei* on barley, *avenae* on oats, *secalis* on rye, *poae* on species of *Poa*, *agropyri* on species of *Agropyron*, and *bromi* on species of *Bromus*. Later, Salmon (1903) and Reed (1905) confirmed much of Marchal's work, and in addition found that the varieties distinguished by him existed in a number of physiological races, each restricted to a particular group of host varieties.

Various investigators, including Mains (1933), Newton and Cherewick (1947), Schlichtling (1939), Waterhouse (1939) working on *Erysiphe graminis tritici* (Marchal), and Honecker (1937), Mains and Dietz (1930), Newton and Cherewick (1947), and Tidd (1937) working on *E. graminis hordei* (Marchal) have since reported the existence of a number of physiologic races. It is now known that a number of varieties of wheat and barley are resistant to one or more of these physiologic races (Mains & Martini, 1932; Newton & Cherewick, 1947; Shands, 1939; Tidd, 1937). A number of genetic factors are involved in the expression of resistance to the physiologic races in the different varieties. Seven different factors for resistance to one race (race 3) have been reported by Stanford and Briggs (1940) in *Hordeum vulgare*, and Mains (1934) has shown that at least two independent factor pairs are associated with mildew resistance in wheat.

Thus, while a considerable amount of information has been collected on the host-parasite relationships of wheat and barley and *Erysiphe graminis*, reports are few on varietal reaction, physiologic specialization and the inheritance of resistance in the genus *Avena*. Reed (1916, 1920) has reported the results of experiments with a large number of different varieties. Altogether, ninety-eight different varieties were tested; of these eighty-eight gave 100 % infection; eight gave 50–98 %, and only two gave no infection. Almost every strain of *A. sativa*, *A. fatua*, *A. sativa orientalis*, *A. nuda*, *A. sterilis*, *A. brevis* and *A. strigosa* was fully infected. The two species *A. homoides* and *A. sempervirens*, which are of no economic importance as grain crop producers, proved free from infection.

Observations of varietal resistance in oats

In the absence of any recorded varietal resistance to powdery mildew in the cultivated Avenae, a study of the relative resistance of a large number of oat varieties to the disease has been undertaken at the Welsh Plant Breeding Station. A fairly extensive collection of oat varieties is maintained by the Station and is grown annually in field nurseries for purposes of assessing the suitability of new introductions as potential parental material for hybridization. The reaction of the varieties to the various diseases is carefully noted, and the incidence of powdery mildew has thus been recorded for each variety in the collection over a period of years. In addition to the field material, a proportion of these varieties, together with a number of special selections and additional varieties representing several different species intended for detailed observation, is sown in late autumn in pots and kept in cool greenhouses throughout the winter.

The varieties grown under field conditions are subject to natural infections and no attempt is made to inoculate the plants artificially. No difficulty is encountered in obtaining really heavy infections in the greenhouse during the late autumn, winter and spring months, and usually the main difficulty is to control the disease after infection where ripe seed is required.

The greenhouse observations are considered to be more reliable than field tests because of the fluctuations in the natural incidence of the disease under field conditions from one year to another. From observations made in the greenhouse during 1950 varieties appear to develop increased resistance to mildew at higher temperatures. Under the cooler conditions prevailing during the autumn, winter and early spring months mildew pustules continue to sporulate with an abundant development of secondary infections. During the summer months, the pustules soon cease to produce conidia and turn into a resistant type of infection with thin mycelial mats and with no secondary infection.

Table 1 shows the infection types obtained on a number of varieties in the field nurseries and in the greenhouses for the three seasons 1948–50.

In recording the observations the following infection classes were recognized:

- − − No visible signs of infection. Microscopically a slight amount of mycelium present.
- − Slight development of mycelium with very slight production of conidia.
- + Moderate development of mycelium with slight production of conidia.
- + + Moderate to abundant development of mycelium accompanied by moderate sporulation.
- + + + Very susceptible, large pustules frequently completely covering the leaf blades and sheaths, abundantly sporulating, no necrotic spots.

Table 1. *Reactions of varieties and selections of oats to infection by powdery mildew* (Erysiphe graminis avenae) *under conditions of natural infection in field nurseries and under cool greenhouse conditions*

	Host reaction					
	Field nursery			Greenhouse		
Variety or selection	1948	1949	1950	1948	1949	1950
Susceptible varieties	+ +	+ +	+ + +	+ + +	+ + +	+ + +
A. sativa L. (spring varieties)						
D 1635*†	. . .	−	+ +	. . .	+ +	+ +
D 1649*†	. . .	−	+ +	. . .	+ +	+ +
O 1746/1/8 (19)*‡	−	−	+	. . .	+	+
O 1747/6/7*‡	−	−	+	. . .	. . .	. . .
O 1747/10/7*‡	−	−	+	+	+	+
O 1751/1/10*‡	−	−	+	±	±	. . .
A. byzantina C. Koch var. Red Algerian	+	+	+ +	+	+	+
A. sativa L × *A. ludoviciana* Dur. (Cc 4146)	. . .	. . .	. . .	−	−	−
A. strigosa (Schreb.) var. *glabrota*	. . .	− −	− −	− −	− −	− −
A. strigosa ssp. *hirtula* (Lagasca)	. . .	. . .	. . .	− −	− −	− −
A. brevis (Roth.) (Cc 1746)	. . .	. . .	. . .	+ +	+ +	+ +
A. longiglumis (Dur.) (Cc 3745)	. . .	. . .	. . .	+	+	+

. . . Not sown.

* New Station-bred selection.

† Derived from a cross between two selections from the hybrids (Record × Trisperma & Potato × Red Rustproof).

‡ Derived from a cross between two selections from the hybrids (Victory × Red Algerina & Red Rustproof × Record).

In the class 'susceptible varieties' are grouped some eighty-three varieties, including all the varieties grown commercially in Britain, and other forms, all of which showed pronounced susceptibility (for list of susceptible varieties see Appendix). With the exception of two tetraploid forms, *A. abyssinica* (Hochst), *A. barbata* (Brot) and the diploid form, *A. wiestii* (Malz.) which were tested only in the greenhouse, the majority of the varieties were tested under both sets of conditions.

It will be noted from Table 1 that the degree of infection in the field varies in the same varieties from one season to the next. Records taken when the plants showed the first signs of culm elongation, and later when the panicles emerged through the leaf sheaths, showed a much heavier infection on the lowermost leaves, and only in the most susceptible varieties such as Clinton, Bond, and Mohawk did infection eventually spread on to the upper foliage. According to Grainger (1947), this is due to the higher relative humidity of the air surrounding the lower regions of the plant. Cherewick, however, attributes the greater prevalence of the disease on the lower leaves to the colder air rather than to higher relative humidities. Of the hexaploid varieties observed in the field, only seven were found to have lower infections than the standard test variety S. 84. These were Red Algerian, D 1635, D 1649, O 1747/10/7, O 1747/6/7, O 1746/1/8 (19), O 1751/1/10. None of the varieties grown in the field showed complete resistance in both the seedling and adult stages for all three seasons. In 1950, when infection reached epidemic proportions in the field nursery, the resistant selections developed some mycelium on the seedling leaves but later proved fairly resistant in the adult stage. In seasons of mild infections these selections exhibited a fairly high degree of resistance in both seedling and adult stages.

In the greenhouse, selections O 1747/10/7, O 1747/6/7, O 1746/1/8 (19) and O 1751/1/10 exhibited a moderate degree of resistance in the seedling stage, and later acquired a fairly high degree of resistance in the adult stage. These selections had been bred and developed by one of us (E. T. J.) as promising lines possessing some degree of resistance to infection in the field. It is worthy of note that all the above-mentioned resistant lines were derived from crosses involving Red Algerian as one of the parents. Selection D 1635 and D 1649, however, when grown in the cool greenhouse, proved to be fairly susceptible to infection in the seedling stage.

In addition to the above-mentioned resistant selections, three other varieties possessing a high degree of resistance were identified in the greenhouse tests. These were Cc 4146, an unidentified hexaploid form believed to have been derived from a natural cross between *A. sativa* × *A. ludoviciana*, and two diploid varieties, *A. strigosa* var. *glabrota* (Cc 4093) and *A. strigosa* ssp. *hirtula* (Cc 3678).

One other noteworthy feature of the varietal reactions to powdery mildew was the extreme susceptibility of the more recently introduced varieties from North America. The new crown rust-resistant variety Clinton, released by Iowa Agricultural Experimental Station in 1945, proved to be one of the most susceptible of all the cultivated varieties tested. In contrast to the smuts and rusts, powdery mildew of oats is of minor importance in the United States and Canada, whilst barley mildew is a common and frequently destructive disease in certain regions. In the greenhouse the colonies of mildew developed first on varieties of American origin, *A. fatua*, and the tetraploid species *A. abyssinica*, followed by the more widely grown North European varieties. As a result of secondary infections these colonies frequently became so numerous as to coalesce, and in consequence extensive areas of the leaf surfaces were completely covered.

Of the diploid species, *A. wiestii* proved to be the most susceptible to infection. *A. brevis* (Cc 1746), S. 75 and S. 171 were slightly less heavily attacked than most varieties of *A. sativa*. *A. strigosa* ssp. *hirtula* (Cc 3678) and *A. strigosa* var. *glabrota* were found to be highly resistant to infection, whilst *A. longiglumis* (Cc 3745) appeared to possess moderate resistance.

During the autumn of 1950 an attempt was made to measure the different degrees of infection in seedlings by means of Grainger's 'standard area' diagrams, which enable the degree of infection to be expressed as a percentage of the total leaf area. The 'standard area' diagrams suggested by Grainger are prepared by spacing ovoid dots upon a leaf-shaped area, the dots representing standard percentages of the leaf area. The frequency distribution and pattern of the infection is classified into eight recognizable percentage infection groups, namely, 0·5, 1·0, 5, 10, 15, 20, 40 and 80 %. Although leaf sizes and shapes, as well as the distribution patterns, vary from the standard diagrams, the similarity of the infections may be fairly readily related to any one of the standard percentage infection groups.

The first three leaves of each plant were compared with these 'standard area' diagrams, and the average of all these readings was taken as the disease measurement of the plant in the seedling stage.

For this purpose, seeds of a number of varieties representing the different degrees of resistance observed previously were sown in pots in the autumn.

Table 2. *A comparison of the infection types on seedlings of different varieties and selections of oats inoculated with* Erysiphe graminis avenae

	Mildew infection as percentage of leaf area			
Variety or selection	1st leaf	2nd leaf	3rd leaf	General mean
Susceptible varieties*	60–80	60–70	60–80	60–70
S. 221	57	55	44	52
S. 84	54	55	45	51
D 1635	57	32	43	44
O 1747/10/7	10	7	10	9
Cc 4146	2	7	6	5
A. fatua (Cc 3872)	53	52	53	53
A. abyssinica (Cc 3403)	67	58	69	64
A. strigosa ssp. *hirtula*	0	0	0	0
A. strigosa var. *glabrota*	1	1	1	1

* Varieties: Clinton, Sun II, S. 147, S. 172, S. 220, S. 225, Victory. Differences in degree of infection not significant.

The seedling plants were first inoculated in the second to third leaf stage. The culture of *Erysiphe graminis* used in these inoculation tests was a composite inoculum collected in the first place from oats growing in the Station's field nurseries and maintained in the greenhouse on seedlings of the susceptible winter variety S. 172.

The mildew spores were dusted on by shaking heavily infected plants over the seedlings at intervals of 4 days. The plants were kept in glass inoculation chambers for 48 hours and afterwards on the open benches of the greenhouse, run at temperatures ranging from 12 to 18° C. Infection was first evident on the variety Clinton after an incubation period of 10 days. The percentage infection for the first leaves was first recorded at the maximum time of development of the disease in the susceptible varieties, and again at fortnightly intervals when readings were also made on the second and third leaves. In all, the plants were kept under observation over a period of 10 weeks. The results, presented in Table 2, are based upon readings taken from at least forty plants in each case.

The three varieties Cc 4146, *A. strigosa* var. *glabrota* and *A. strigosa* ssp. *hirtula* were outstanding for their marked resistance to infection. Except for a very mild necrotic reaction, no visible signs of infection were observed in *A. strigosa* ssp. *hirtula*, while *A. strigosa* var. *glabrota* allowed slight development of mycelium in a few isolated spots on the leaves in the early stages of development. The hexaploid variety, Cc 4146, also proved highly resistant to infection but when removed into a cooler greenhouse, later developed a few pustules which sporulated freely. Further experimental evidence is being sought to ascertain whether the later development of mycelium on this variety was due to temperature effect or to the appearance of another physiologic race of *Erysiphe graminis avenae*.

Little or no resistance to infection was found in selection D 1635. Selection O 1747/10/7 allowed a moderate development of mycelium with some sporulation in the early stages. This was accompanied later by marked necrosis which arrested any subsequent development of the fungus through mycelial spread and by secondary infection. This necrotic host reaction which was most marked in this variety and the resistant variety Cc 4146 appears to be associated with a particular type of resistance. It is suggested by Smith and Blair (1950) that the reaction of the chlorenchyma tissue underlying invaded epidermal cells plays an important part in resistance in varieties showing large necrotic lesions, and that the necrotic lesions themselves are caused either by toxins liberated by the fungus within the cells, or by a rapid loss of nutrients withdrawn by the parasite.

All the other varieties tested proved to be susceptible, although slight differences were observed in the interval between the date of inoculation and development of infection on the leaf surfaces. The fungus appeared first in Clinton, Sun II and the two stiff, short-strawed varieties, S.172 and S. 225, which later proved to be the most heavily attacked varieties. Homma (1937) concluded that certain morphological characters such as frequency of hairs on the surface of the leaves and thickness of epidermal cell walls influenced varietal susceptibility in wheat. Smith and Blair (1950), however, obtained no evidence of any correlation between these morphological characters and varietal resistance.

BREEDING MILDEW-RESISTANT VARIETIES

The varietal reactions to *E. graminis avenae*, as shown in the foregoing tables, indicate that there is no lack of mildew-resistant breeding material within the genus. Several workers have already demonstrated that resistance to mildew in wheat and barley behaves as a Mendelian character, and that high yielding mildew-resistant varieties with desirable agricultural characters can be produced by hybridization.

The possibility of combining, by hybridization, the factors for resistance with desirable agronomic characters into one improved strain makes the knowledge of the interrelationships of these factors of great importance to the breeder. Combination of resistance to crown rust and powdery mildew with desirable agronomic characters has become an important aspect of the Station's oat-breeding programme. To do this systematically it has been necessary to study the inheritance of resistance to both powdery mildew and crown rust, and this has only recently been made possible for powdery mildew with the identification of resistance in Cc 4146, *glabrota* and *Avena strigosa* ssp. *hirtula*. Although crosses made between selection O 1747/10/7 and susceptible varieties had already shown that resistance to mildew behaves as a heritable character, a satisfactory analysis of the F_2 and F_3 progenies could not be accomplished in the greenhouse.

Crosses were made between the mildew-resistant variety Cc 4146 and a crown rust-resistant selection, R 464, for purposes of studying the mode of inheritance of resistance to both crown rust and powdery mildew. R 464 is a selection from Marvellous × Green Russian-Bond, and possesses the crown rust resistance of the Bond parent. It is completely resistant to all the prevalent races of crown rust found at Aberystwyth, but is very susceptible to powdery mildew. The crosses were made during the summer of 1949, and one of the F_1 generation plants was grown under artificial lighting the following winter while the others were grown under greenhouse conditions in 1950. The F_1 plants, as well as both parents, were inoculated with crown rust and mildew spores. In the F_1 resistance to crown rust was dominant, although the degree of resistance was slightly lower than in the parental variety R 464. The reaction to infection by mildew was intermediate in character. The F_1 hybrid plant grown under artificial illumination produced only twenty-four grains, and consequently the evidence from segregates for resistance to mildew in this cross is at present confined to a small number of F_2 plants. Fairly large F_3 populations from each F_2 were, however, tested during the autumn of 1950.

The F_2 and F_3 progenies were studied for reaction to composite inoculums of rust and mildew by inoculating the first leaf with crown rust, and after readings were completed the plants were dusted with mildew spores. After dusting, the plants were placed under glass chambers for inoculation, and the mildew readings made in about 3–4 weeks' time. The crown rust readings were taken 10 days after inoculation.

Seedlings were classified according to their rust reaction by using the infection types described by Murphy (1935). Infection types 0, 1 and 2 were classified as resistant, while 3 and 4 were classified as susceptible.

To determine the reaction to mildew the infection types observed in the F_2 generation were classified according to the system suggested by Mains and Dietz (1930). Plants showing infection types 3 and 4 were considered susceptible, those showing 0 or 1 resistant. A high proportion of the F_2 plants, however, ranged from type 2 to type 3 in their reaction and were grouped as intermediates. As shown in Table 3, observed segregation in the F_3 generation gave a close fit to a 1 resistant : 2 heterozygous : 1 susceptible ratio, thus indicating that resistance to mildew in this cross is governed by a single genetic factor. An analysis of the F_2 and F_3 progenies indicated that the intermediate types of infection (types 2–3) recorded in the F_2 represented the heterozygous plants, type 4 and a few type 3 represented homozygous susceptible plants, and types 0 and 1 homozygous resistant plants. By classifying every F_2 plant on which any mildew was found as susceptible, the results gave a close fit to a 3 susceptible : 1 resistant ratio. This season, larger F_2 progenies of this cross are available for further study.

Observed segregation for reaction to crown rust in crosses between R 464 and other susceptible varieties has shown that two complementary dominant factors govern resistance in selection no. R 464. From the very limited data already available from the cross, Cc 4146 × R 464, it appears that powdery mildew reaction and factors governing crown rust resistance are inherited independently of each other and of some other plant characters (Griffiths, unpublished data).

F_2 and F_3 progenies of the cross *A. strigosa* ssp. *hirtula* × *A. brevis* were also studied for reaction to mildew. *A. strigosa* ssp. *hirtula* possesses a high degree of resistance while *A. brevis* is susceptible (see Table 1). As shown in Table 3, observed segregation for reaction in this cross gave a close fit to a 1 resistant : 2 heterozygous : 1 susceptible ratio, indicating that resistance to mildew in the diploid species *A. strigosa* ssp. *hirtula* is also governed by a single factor pair.

Table 3. *Inheritance of resistance to* Erysiphe graminis avenae *in two crosses grown in the greenhouse*

			No. of plants or families					
Cross	Generation	Observed or expected*	Resistant	Segregating or intermediate	Susceptible	Total	χ^2	*P*
Cc 4146 × R 464	F_2	Observed	5	13	6	24	0·249	0·9–0·8
	F_3	Observed	5	13	6	24	0·249	0·9–0·8
		Expected	6	12	6	24	—	—
A. strigosa ssp. *hirtula* × *A. brevis*	F_2	Observed	22	39	23	84	0·462	0·8–0·7
	F_3	Observed	19	44	21	84	0·285	0·9–0·8
		Expected	21	42	21	84	—	—

* Expected ratios in F_2 and F_3 calculated on the basis of 1 : 2 : 1.

With the identification of new factors governing resistance to mildew in oats a really effective approach towards the control of this disease can be made by breeding. It should thus be possible without much difficulty to combine resistance to both mildew and crown rust with other desirable agronomic characters in one or more suitable varieties adapted to the requirements of British agriculture.

APPENDIX

A. sativa L. Vars.: Advance, Ajax, Andrew, Anthony, Ayr Bounty, Banner, Bannock, Benton, Black Bell III, Black Supreme, Bonda, Bonham, Borris Opus, Bountiful, Ceirch-du-Bach, Cherokee, Clinton, Craig's Afterlea, Grey Winter, Eagle, Early Miller, Eaton, Engelbrekt, Foxglove, Golden Rain II, Green Mountain, Green Russian, Hawkeye, Laurel, Letoria, Marian, Marvellous, Mindo, Mohawk, Nemaha, New Minor, Nortex, Onward, Picton, Radnorshire Sprig, Rangler, Richland Iowa (108), Ruakura, Rustler, Sac, Scotch Potato, Shelby, Sixty Day, Star, Sun II, Sunrise, S. 81, S. 84, S. 147, S. 172, S. 220, S. 221, S. 225, selection numbers D 1670, D 2960 and D 2973, Tabor, Tama, Tennessee selection, Vanguard, Victoria, Victory, White Tartar, Zephyr.

A. byzantina C. Koch. Vars.: Bond, Culberson, Red Rustproof.

A. fatua L. Vars.: Ssp. *meridionalis* var. *grandis* (Cc 3872).

A. nuda L. Vars.: Liberty and two unnamed forms (Cc 3932 and 3937).
A. abyssinica (Hochst). Vars.: Two unnamed varieties (Cc 3403 and 4015).
A. strigosa (Schreb.). Vars.: S. 78 and S. 75.
A. strigosa × *A. brevis*. Var.: S. 171.
A. wiestii (Malz.). Unnamed variety (Cc 1790).

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SEPTORIA ARMERIAE ALLESCH., THE CAUSE OF A LEAF-SPOT DISEASE OF 'BEES RUBY' *ARMERIA*

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(With 4 Text-figures)

Septoria armeriae Allesch., a little-known fungus originally described from Greenland, is widely distributed in Britain. It grows slowly in culture, producing abundant conidia and, in old cultures on malt agar, aggregates of small spherical sclerotia. Both conidia and pycnospores are capable of causing infection; penetration by the germ tubes being apparently stomatal and not involving the formation of appressoria. The pycnidia are exclusively substomatal, goblet-shaped with a wide ostiole encircled by the guard cells, 50–100 μ (av. 80 μ) in diameter; their development is pseudopycnidial, with the production initially of a tuft of hyphae bearing conidia. The pycnospores are 9–25 μ (av. 16 μ) long by 1·5 μ wide, mainly uniseptate, not significantly different from the conidia.

A hitherto undescribed leaf-spot disease of 'Bees Ruby' *Armeria*† was noted in a nursery in Sheffield in August 1946. The associated fungus, though fairly readily identifiable as a species of *Septoria*, nevertheless showed certain unusual features in its pycnidial development. Accordingly, the disease was suggested for investigation by a student in 1947–8. Further observations were made by the writer, in Sheffield during 1949 and in Bristol from 1950 onwards.

SYMPTOMS

The symptoms are those of a typical leaf-spot disease. The spots are more or less circular, 5–10 mm. in diameter, brown, and sharply defined by a purplish border. The surrounding tissues commonly become flushed with red, though this is not a specific response to the presence of the fungus. When a spot occurs at the tip of the leaf, or when two or more spots are close together or have coalesced, the affected area as a whole becomes yellow and eventually shrivels. Under damp conditions, the centre of each spot bears numerous closely crowded spore horns which are individually just visible to the naked eye, of a dull appearance and slightly yellow. Somewhat flattened in section, they are extruded through the stomata from the amphigenous, mainly epiphyllous, pycnidia. There is no zonation, except that on the edge of the lesion the spore horns are replaced by minute, glistening white, mycelial tufts. Under a hand-lens, transitional stages can be seen in which at the centre of the tuft there is a spore horn in process of extrusion. The microscopic characters of the fungus are described later.

In the affected nursery at Sheffield, there were originally three beds each of about two hundred plants. At the first detailed examination, in May 1947, all the plants were diseased to a greater or less extent: the outermost leaves, especially those touching the soil, being the ones principally affected. As the lesions were mostly old and dry, the disease seemed of little consequence. A few weeks later, after a rainy spell, it was much more noticeable. Many small, incipient, lesions were seen near the tips and at the margins of the leaves, and on the older lesions there was an abundant production of spore horns. A similar observation was made on several occasions subsequently, indicating a rapid spread of the disease in damp weather during the summer months. There was little evidence of spread during the winter, though at no time of the year were the plants entirely free from the disease.

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* Formerly of the Botany Department, University of Sheffield.

† A garden plant of uncertain origin, probably *Armeria gaditana* × *A. maritima* (W. T. Stearn, *in litt.*). Sometimes listed as a form of '*A. cephalotes*'.

More limited observations at Bristol were in full agreement with the above. Plants affected by the disease were also received from a nursery in Cheshire; and to these occurrences must be added the first provisional record in Britain, from London in 1935 (Moore, 1943; and *in litt.*), which has been confirmed by examination of material preserved in the Kew Herbarium. Thus, the disease is widely distributed in England, and seems likely to be found wherever the plant is in cultivation.

GROWTH AND MORPHOLOGY IN CULTURE

Growth. The fungus was isolated on several occasions, either directly from the spore horns, or from portions of infected tissue after surface sterilization. The medium usually employed was 2 % malt agar. Colonies from the dilution plates could be transferred to slants after 2–3 days, being recognizable at this stage by their small size (a fraction of a millimetre only), by their narrow, tapering and sinuous hyphae, and by the copious production of secondary spores. Growth remains slow and the colonies rarely exceed 1 cm. in diameter after 4–5 weeks, when they are pinkish or grey in colour with a slightly corrugated surface and generally rather moist and bacterial appearance, with little or no aerial mycelium. The subsequent development on malt agar is rather variable, depending on the isolate and on the precise conditions of the medium. Typically, it involves the production of an abundant, fluffy, white or pink, aerial mycelium overlying a wrinkled leathery crust of intermingled hyphae and spores. This stage is reached at about 10 weeks, when the colony may have covered about half the surface of the slant. Thereafter, though there may be further lateral spread of the aerial mycelium, in the centre of the colony it becomes relatively scanty and may disappear entirely; whilst the surface beneath becomes gradually transformed into aggregates of black spherical sclerotia. After 6 months, this process is usually complete. Sclerotia apparently fail to develop on potato dextrose, oatmeal, and *Armeria* leaf-extract agars, on which media the growth is in other respects similar to that on malt agar. Again, however, there are considerable differences in colour and other features of the colonies on the various media, as also between different isolates growing on the same medium; though in any extended series of cultures a whole range of intermediate forms occurs, so that their classification becomes impossible.

Mycelial types. The aerial mycelium of the young colonies on malt agar is composed of extremely fine, colourless, tapering, sinuous hyphae from 1·5 μ to less than 1 μ wide. The older, submerged hyphae are somewhat stouter, up to 3–4 μ wide, and eventually become dark coloured. They are closely and irregularly branched. In colonies from 16 weeks and onwards, some of the narrower, colourless, submerged hyphae exhibit a series of irregular, moniliform swellings which may develop into thick-walled terminal and intercalary chlamydospores.

Conidia. The spores in culture are hyaline, rod-shaped, straight or slightly curved, blunt, continuous or uniseptate, 10–20 μ long by 1·5 μ wide. They are formed successively from small projections at the sides of the hyphae or at the tips of short lateral branches (Fig. 1), and increase rapidly by budding.

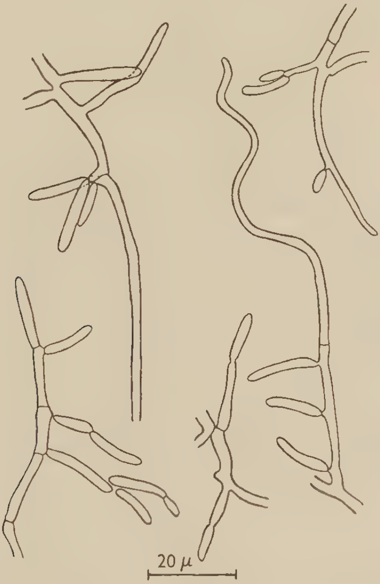

Fig. 1. Hyphae from 72-hour culture on malt agar viewed *in situ*, showing abstriction of conidia.

Sclerotia. These are approximately spherical, 50–130 μ (av. 85 μ) in diameter. They consist of an outer layer some 15 μ wide, composed of thick-walled dark brown hyphae, enclosing the hyaline mycelial contents. At their first appearance, they occur in aggregates each about a millimetre across; later a more or less continuous layer may be formed. No pycnidia were seen in culture, and it is possible that the sclerotia represent an abortive phase in the development of these, or of some other type of fructification.

SPORE GERMINATION

Mode of germination. Pycnospores (see below) and conidia from culture were germinated by the hanging-drop method in water, 2 % sucrose solution, and 2 % potato dextrose agar; and were examined after 24, 48 and 72 hours. Both types of spore increase in width before germinating and, if previously aseptate, develop a single cross-wall. Germination takes place at any part of the spore, and may occur at two or more points at the same time. In water, germination is slow and only the conidia show any tendency to produce secondary spores; possibly due to the unavoidable transfer of nutrients from the original cultures. Further development ceases after about 3 days. In the nutrient solutions, germination is very rapid and, on the whole, it is the pycnospores that develop more vigorously. Colonies of both types, however, produce abundant secondary spores which themselves immediately reproduce by budding; so that development can only be followed in detail for the first 48 hours.

Longevity of pycnospores. Spores from dried leaves bearing spore horns were tested at monthly intervals for their ability to germinate in drops of 2 % malt agar. Approximately 75 % of the spores germinated at the end of each of the first 3 months, 50 % at the fourth, 20 % at the fifth, and 10 % or less at the sixth, when the experiment was discontinued.

Inoculation experiments

Proof of pathogenicity. The disease was reproduced on potted plants, either by spraying with suspensions of pycnospores or conidia in distilled water, or by placing on the leaves small pieces of agar medium on which the fungus was growing in pure culture. The former method was more uniformly successful. The plants were maintained in a saturated atmosphere for at least 48 hours after inoculation. During the summer, the inoculations were carried out in the laboratory and the plants were then left on the roof outside; at other times of the year, they were maintained throughout in a cool greenhouse. Large plants, forming hemispherical rosettes about 30 cm. across, were given several treatments simultaneously by dividing the foliage into tufts, each enclosed in a glass lamp-shade or piece of wide-bore tubing (which can be lined with damp filter-paper if desired). Owing to the almost universal occurrence of the disease among the plants available for study in Sheffield, it was not always possible to ensure that the controls remained free from infection, unless special precautions were taken. This is illustrated by two experiments, the results of which are summarized in Table 1.

Each experiment involved three large plants; those of the first experiment were equally divided so that part of each plant served as a control to the rest (in plants A and B sprayed with the sterile water, in plant C inoculated with the agar medium only); and those of the second experiment were of approximately equal size. Thus, the results are mutually comparable within each row of the table. For the first experiment, the plants were carefully examined and all dead, yellowing, or spotted leaves were removed 1 week before, and again immediately prior to, inoculation. Yellowing and senescent leaves were also removed afterwards, at regular intervals. The controls, nevertheless, became slightly infected. For the second experiment, as an additional precaution, all the outer leaves touching the soil were removed and further contact with soil was prevented; the preliminary period of observation, moreover, was extended to 3 weeks. These measures were successful, allowing the controls to remain healthy.

Table 1. *Results of inoculation experiments*

	Inoculated			
	Spores	Conidia	Colony	Control
First experiment (recorded 22 July 1947, 4 weeks after inoculation)				
Plant A (six parts):				
Leaves wounded	51/8	145/24	—	2/1
Leaves intact	60/13	103/13	—	8/5
Av.	90/14			5/3
Plant B (three parts):				
Leaves intact	123/22	130/22	—	14/7
Av.	126/22			14/7
Plant C (two parts)	—	—	71/31	13/7
Second experiment (recorded 10 December 1947, 3 weeks after inoculation)				
Three separate plants	19/15	2/2	—	0/0

In each entry, the *numerator* represents the total number of lesions and the *denominator* the number of leaves on which they occur. An entire plant, of the size used, may be regarded as having some 350 mature leaves.

The experiments collectively afford adequate evidence of pathogenicity, confirmed by the successful re-isolation of the fungus. No satisfactory comparison can be made as between the effectiveness of pycnospores and of culture conidia in causing infection, because the density of the spore suspensions was not standardized. Wounding the leaves, as by scratching with a needle in the first experiment, has apparently no effect on the results of inoculation.

Mode of infection. Several attempts were made to study the details of penetration, on detached leaves of various ages and on whole shoots maintained in Knop's solution. Both pycnospores and culture conidia were employed. The spore suspensions, in distilled water, were applied either by means of an atomizer, or to marked areas, by means of a platinum loop. A saturated atmosphere was maintained for 2 or 3 days after inoculation; in some experiments allowing the droplets of spore suspension to evaporate first. Examination was carried out entirely on unsectioned material, using the cotton blue/lacto-phenol method. Whole leaf portions do not clear well, and epidermal slicings were preferred. The best results were obtained by fixation in hot absolute alcohol and then, using a very weak solution of the stain in lactophenol, clearing and staining in one operation by heating on the slide, under a coverslip. In these experiments, there was no evidence of cuticular penetration. Very few instances of stomatal penetration were seen; though several hundred germ tubes were observed crossing the stomata which they reached, apparently, at random. Penetration was effected either by the tip of a main hypha or by a short lateral branch; the hyphae being of the normal width, about 1–1·5 μ. No appressoria or other modifications were seen. It is concluded that the normal mode of entry is probably by stomatal penetration in the manner described, but the optimum conditions for this have still to be discovered.

MORPHOLOGY IN THE HOST

Stages in pycnidial development. In the early stages of infection, or on the advancing edge of a lesion, there is a copiously branched mycelium of fine, septate hyphae about 1·5 μ across, ramifying in the intercellular spaces of the mesophyll without haustoria. Later, as the tissues begin to disintegrate, the cells are penetrated. Just before this condition is reached, aggregations of mycelium are formed immediately beneath the stomata (Fig. 2A). These are the first stage in the development of pycnidia. They gradually increase in size and become more compact, forcing the guard cells apart and giving rise to a tuft of short, branched, aerial hyphae from which, under damp conditions, spores are abstricted (Fig. 2B). This is the tufted stage previously described, and with its further enlargement the hyphae appear to be entirely breaking up into spores; though the condition on the whole is still 'dry' rather than 'slimy' (Mason, 1937). The base of the tuft, beneath the guard cells, is more or less hyaline and undifferentiated (Fig. 2C). The subsequent development involves the gradual conversion of this, essentially sporodochial, phase into a pycnidium; spore production becoming localized and intensified to initiate a compact, gelatinous, spore tendril; and the basal layer becoming hollowed out and differentiated into a thin, dark coloured, pycnidial wall (Fig. 2D).

Mature pycnidia and pycnospores. The mature pycnidia (Fig. 2E, F) are irregularly globose, about 80 μ (50–100 μ) in diameter, with the wall up to 9 μ thick. They have no ostiole as a distinct morphological entity: the pycnidial wall merely thins out above, and ends in contact with the guard cells (which are invariably recognizable) or with the accessory cells adjacent to them. The aperture thus remaining tends to be oval in outline, with an average width of from 0·5 to 0·6 times the total diameter of the pycnidium (Fig. 3). The pycnospores (Fig. 4) are hyaline, straight or slightly curved, mainly uniseptate, 9–25 μ long by 1·5 μ wide. A typical average for the length of twenty-five spores measured at random was 16·2 ± 0·6 μ; which was not significantly different from the average length of the spores from the earlier tufted stage in pycnidial development, nor from that of the conidia from a 6-week colony on malt agar. Morphologically, the pycnospores and the other spore types are indistinguishable.

DISCUSSION ON TAXONOMY

The taxonomy of the fungus may be discussed at both the generic and specific levels. Generically, the most important features are the development and structure of the pycnidia; whilst specifically, in the present state of classification, the matter rests mainly on the identity of the host plant. In this instance, however, perhaps more than in most, the pycnidial characters themselves are conditioned by the host morphology. It should be borne in mind that the leaves, as in other *Armeria* species, are thick and evergreen, with relatively small intercellular (and substomatal) spaces; the epidermal cells are of simple outline and heavily cuticularized; and the stomata, which occur on both surfaces, are level or slightly raised, with

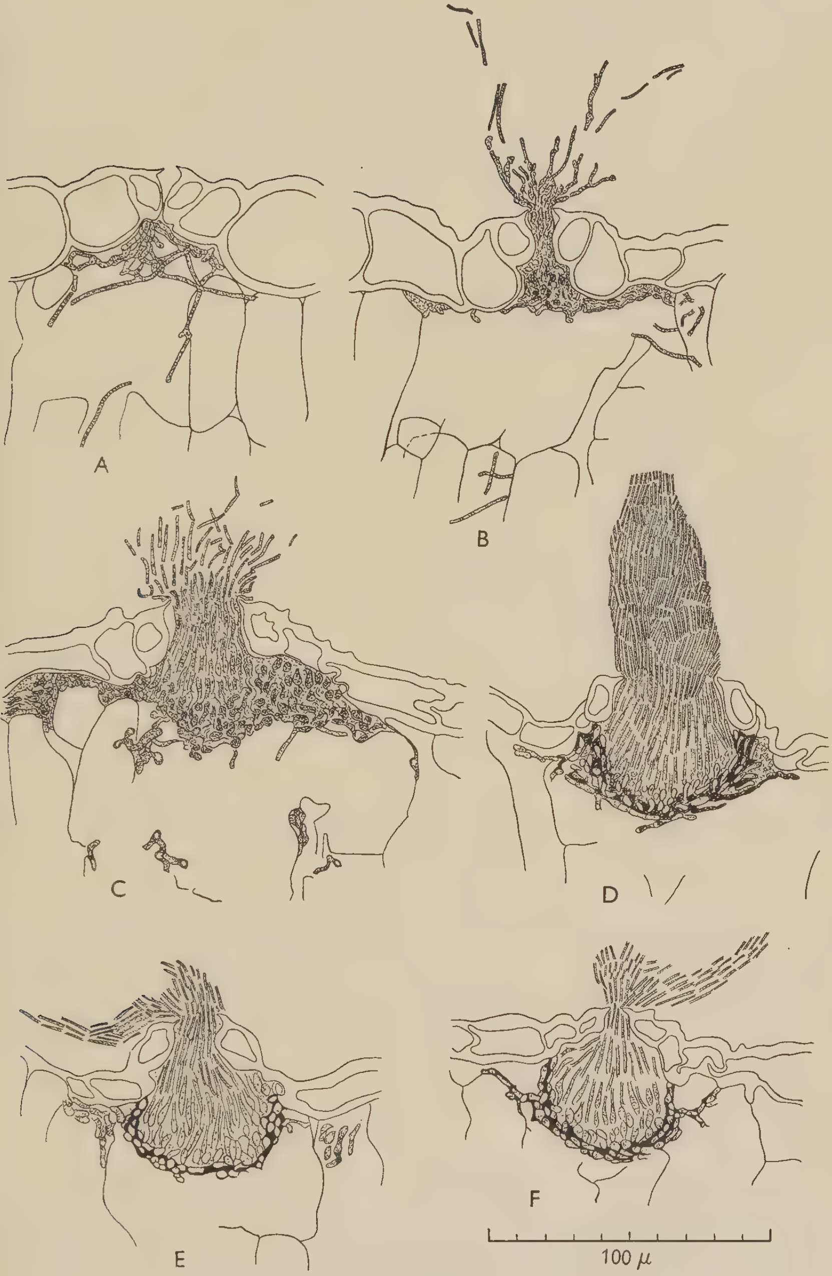

Fig. 2. A–F, stages in pycnidial development, from transverse sections of leaf A–C at 8 μ, D, F at 5 μ, E at 3 μ. (For further explanation see text.)

narrow, paracytic (Metcalfe & Chalk, 1950), accessory cells not much wider than the guard cells.

The pycnidia, being exclusively substomatal, develop throughout in contact with the guard cells, and it is the latter which eventually, stretched as far as they are able, serve as a rim to the ostiole. The width of the opening thus encircled is an unusually large fraction of the diameter of the entire pycnidium, 0·5 to 0·6, as compared with the more usual 'ostiolar ratio' for species of *Septoria* of between 0·2 and 0·4. The mature pycnidium, strictly speaking, is goblet-shaped rather than globose; a fact which, coupled with the decreased thickness of the wall towards the top, suggests a comparison with those species more frequently assigned to *Phleospora* Wallr. than to *Septoria*. The comparison is strengthened by taking into account the earliest spore horn stage, before the fruit body has become invaginated; and, considering the ultimate origin of the pycnidia, symphyogenously to produce at first a tuft of hyphae bearing aerial conidia, it may be extended to the sequence: *Ramularia* → *Cylindrosporium* → *Phleospora* → *Septoria*. In fact, there is here a very good example of 'pseudopycnidial' development in the sense of Potebnia (1910). Diedicke's (1912) instance, of *Phleospora jaapiana* P. Magn. interpreted as a typical *Ramularia*, and Potebnia's own discussion and figures of *Septoria* (= *Phleospora*) *astragali* Desm., *Phleospora* (= *Septoria*) *caraganae* Jacz., and *Phleospora orobi* Potebn. (= *Cylindrosporium orobicolum* Bubak), may be cited as of particular relevance. Thus, the fungus may be accepted as a species of *Septoria*, and as one favouring the wider interpretation of this genus to

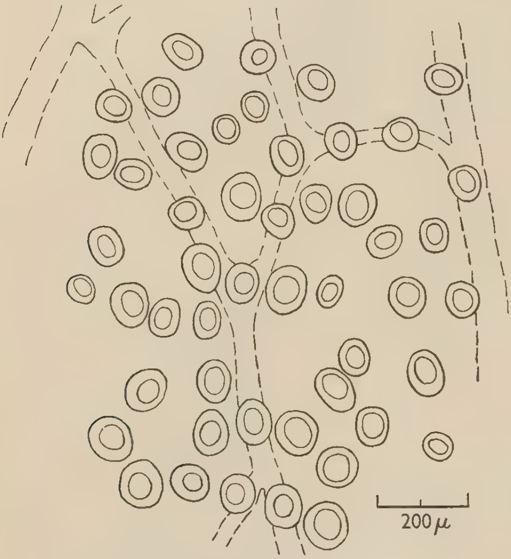

Fig. 3

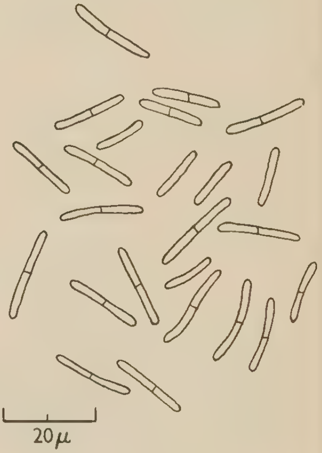

Fig. 4

Fig. 3. Surface view of part of old lesion, cleared in lacto-phenol, with pycnidia in outline. (The limits of the ostiole are less clearly defined than is apparent from the drawing.)

Fig. 4. Pycnospores from naturally extruded spore horns, mounted in lacto-phenol.

include *Phleospora*. The identification is confirmed by the cultural characters (Potebnia, 1910), in which there is a general resemblance, for example, to certain graminicolous species (Weber, 1922–3); and particularly, in the production of sclerotia, to *Septoria oxyspora* Penz. & Sacc. as recently described by McKay (1946).

Identification of the species is comparatively straightforward; the main problem being the unaccountable paucity of the records. *S. armeriae* Allesch. is the only species on this host genus (or other Plumbaginaceae) in Garman and Stevens's (1920) tabulation and, apparently, none has been added subsequently. Allescher and Hennings (1897) first recorded it from Greenland where it was collected in 1893 on the dead leaves of *Armeria vulgaris* var. *sibirica*; mostly, in association with the fungus (also newly described) *Phyllosticta armeriae* Allesch. The brief diagnosis (*Sacc. Syll.* XIV, 3844) may be quoted in full:

> Peritheciis amphigenis, plurimum epiphyllis, sparsis, erumpentibus, lenticularibus, punctiformibus, nigris; sporulis bacillaribus, rectis, utrinque obtusis, continuis, eguttulatis, longitudine varia $8–30 \times 1\frac{1}{2}–2\,\mu$.

Thereafter, there seem to be only two or three more published records of this fungus in Europe; namely, those on *Armeria plantaginea* in Italy and France, quoted by Stevenson (1926), and the provisional one from this country in 1935 (Moore, 1943). In the absence of any authentic material in the national Herbaria, and as Allescher's type has proved unobtainable, it has been necessary to name the present collections by comparison with the diagnosis. The agreement, though not absolute, is sufficiently close to leave little doubt but that the same fungus is involved; though it should be noted that, so far, there have been no indications of the associated *Phyllosticta*. *Septoria armeriae* Allesch., at any rate, may now be accepted as widely distributed in Britain. Collections under this name are available in the University of Sheffield Mycological Herbarium, and a duplicate of one of them (no. 91, of 8 July 1947) has been deposited at Kew.

In preparing this account, I have drawn freely upon the results of an investigation carried out by Miss Dorothy McGowan, working under my direction as a student in the Botany Department of the University of Sheffield. It is a pleasure to acknowledge the value of her observations. I am indebted to the Director of the Royal Botanic Gardens, Kew, for the loan of specimens from the Herbarium; and to Dr R. W. G. Dennis for help with the literature.

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(*Accepted for publication* 20 *August* 1951)

THE USE OF COMMERCIAL 'PECTOZYME' IN THE ANATOMICAL STUDY OF PARASITIC FUNGI WITHIN PLANT TISSUES

By JOAN FRAYMOUTH and LILIAN E. HAWKER
Department of Botany, University of Bristol

An enzyme extract prepared from commercial 'Pectozyme' has proved to be a useful tool in a study of the haustoria of the downy mildews, now in progress.

A 2% solution of the commercial enzyme in citrate buffer, pH 4, is shaken intermittently for an hour at 25° C. After filtering it is added to an equal volume of water tinged with aniline blue.

Freezing microtome or hand sections of fresh or preserved material are mounted in the enzyme extract. After 4–6 hr. the fungus has absorbed the dye so that the hyphae and haustoria are clearly differentiated. Slight pressure on the cover-slip separates the host cells so that the relative positions of fungal and host elements are readily seen. After 24 hr. the host cells are usually almost entirely disintegrated, while the stained hyphae and haustoria remain intact. With longer periods, which vary with the material, the hyphae themselves become plasmolysed and disintegrated.

Thanks are due to Dr A. Pollard of Long Ashton Research Station and Dr E. W. Yemm of this Department for advice and help.

REVIEWS

Researches on Fungi. Vol. VII. The Sexual Process in the Uredinales. By the late A. H. R. BULLER. (Toronto: University of Toronto Press, 1950.) Pp. xx + 458, portrait and 124 text-figures. $ 13.

> 'Set up a monument to him
> Say on a slab of schist
> He was an ardent Spor-o-bol-
> O-my-cet-o-log-ist.'

So runs Buller's epitaph written by him a few years before he died. It is fitting. It strikes the keynote of this great mycologist—this ardent student of fungi as living organisms actively engaged in spore dispersal.

This last volume of his *Researches*, published six years after his death, will be read by mycologists the world over with the keenest pleasure, but with a haunting regret that this is indeed the last, for although a number of separate chapters for a further volume exist in manuscript, it is unlikely that these can be organized into an eighth volume.

Of course vol. VII, like all its predecessors, could have been shorter. Indeed all that is said could very adequately have been put in a third of the space. But in condensation something would have been lost—the attitude of Buller towards his subject. All his volumes contain, if somewhat diffused, a great amount of most valuable, critical and original observation, but they are something more. In the truest sense they are creative works of art ranking in mycological literature with the *Carpologia Fungorum* of the Tulasne brothers and *Untersuchungen aus dem Gesammtgebeit der Mykologie* of Brefeld.

Buller's vol. VII is concerned with the sexual process in Rusts. The discovery of the function of pycnidia was due to the elegant experiments of Craigie (1927), and his results have had a fundamental influence on later researches on rust fungi. But it must not be forgotten that Craigie acted on a suggestion by Buller. There is a delightful account of an historic scene in the greenhouse of the Dominion Rust Laboratory: 'I went into the greenhouse and looked around. On the benches were a number of young sunflower plants which had been inoculated with basidiospores...and whose leaves bore isolated...pustules of *Puccinia helianthi.* All at once I heard a fly...buzzing near me and then I saw it settle on a sunflower leaf, run up to a rust pustule, suck up some of the drops of nectar protruding from the pycnidia and then fly off to another sunflower leaf where it again visited a rust pustule and again sucked up some of the nectar. Immediately thereafter, the solution of the problem of the function of the pycnidia flashed into my mind. About five minutes later Mr Craigie joined me. I turned my back on the fly and asked Mr Craigie if he knew what was the function of the pycnidia. He said that they were supposed to be functionless male organs....I then directed his attention to the solitary fly in the greenhouse and we saw it visit two rust pustules in succession....I then said: "The solution of the problem of the function of the pycnium is an entomological one. Copy the action of the fly."' And that is how it all began.

Thereafter Buller himself became extremely interested in sexuality of rusts and this book gives a full account of his own meditations, anatomical observations and experimental researches. He gives a detailed description of the structure of the pycnidia and proto-aecidia formed on the barberry leaf as the result of infection with a single basidiospore of *P. graminis.* There is a clear account of the stiff periphyses and the longer flexuous hyphae both projecting from the pycnidium into the droplet of sugary, sweet-smelling nectar containing the extruded pycnidiospores. The fusion of these with the flexuous hyphae of opposite sign is fully described and discussed. Some of his pictures of pycnidia seen in surface view of the inflected leaf are extremely attractive and look rather like expanded sea-anemones in an aquarium.

Many academic mycologists have found it somewhat difficult to reconcile the facts of rust sexuality elucidated by the experiments of Craigie with the older cytological pictures of Blackman and of Christman showing cell fusions and nuclear migrations between adjacent cells of the aecidium primordium leading to the development of a palisade of bi-nucleate cells. Buller faced this difficulty and gave some good advice to the rust cytologist: 'Before a cytologist begins to pickle material of a *Puccinia* or a *Uromyces* with a view to embedding it in wax and slicing it up with a microtome he would do well to study both his Rust Fungus and the invaded host-tissue in the living condition.' He concluded 'that the supposed chess-board-like arrangement of (+) and (−) fertile cells in the proto-aecidium had been a completely erroneous conception'.

British mycologists will be especially pleased to find a chapter on '*Puccinia suaveolens* and its sexual process'. The common thistle with its spindly rusted shoots in spring densely covered with sweet-scented pycnidia always arouses interest in students of fungi. The rather complicated but convincing story of the origin and behaviour of the various types of systemic and local infections in *Cirsium arvense* has been worked out by a series of very simple but elegant experiments.

One important generalization concerning rusts emerges from Buller's work namely that all rusts with a pycnidial stage appear to be heterothallic whilst homothallic forms are probably to be found only in the short-cycled species without pycnidia.

Because of paper difficulties in this country vol. VII has been produced in Canada by the University of Toronto Press instead of by Longmans, Green and Co. The form of the previous volumes has been retained with their high quality paper which allows good reproduction of Buller's delightful drawings and the many excellent photographs. Much credit goes to Dr Bisby who has edited the work, and to Dr W. F. Hanna for preparing a full index in keeping with those which Buller himself made with so much care in earlier volumes.

Vol. VII is a perfect swan-song. No 'slab of schist' is needed to perpetuate the memory of this great mycologist. Whilst the human race continues to study fungi Buller's *Researches* will remain his monument, a source of wonder and excitement to generation after generation of mycologists and always the same insistent message will be conveyed: *study your fungus as a living mechanism.*

C. T. INGOLD

Les Urédinées (ou Rouilles des végétaux). Tome 2. *Genre* Uromyces. By A. L. GUYOT. 331 pp., 72 text-figures. *Uredineana*. Tome 3. Edited by A. L. GUYOT. 482 pp., numerous text-figures. [*Encyclopédie Mycologique*. Tome 15.] (Paris: Paul Lechevalier, 1 June 1951.) Price (not sold separately) Frs. 7200.

In order to set the works under review in perspective, it is necessary to recall that the first volume of Guyot's *Les Urédinées* (dealing with part of the genus *Uromyces*) was published in 1938. In the following year the first volume of *Uredineana* appeared as a supplement and in 1946 a second volume of this 'Recueil d'études systématiques et biologiques sur les Urédinées du Globe' was issued. The 1951 instalments of this bibliographically complex series comprise an account of species of *Uromyces* which parasitize members of the Liliaceae, Amaryllidaceae, Iridaceae, Chenopodiaceae, Plumbaginaceae, Compositae, Rosaceae, Geraniaceae, Primulaceae, Scrophulariaceae and Valerianaceae together with, in *Uredineana*, seventeen original papers and notes by various authors, corrections and additions to the second volume of *Les Urédinées*, the third supplement to volume one of that work, the fourth and fifth supplements to its bibliography, and other matter.

Guyot's exhaustive monographic treatment of *Uromyces* is a notable and useful addition to mycological literature and a journal devoted to rusts will probably be welcome to uredinologists. It is, however, rather unfortunate that the two publications are linked together so as to make the price of *Les Urédinées* prohibitive for most mycologists and plant pathologists and, in these days of restricted budgets, even for less specialized libraries.

G. C. AINSWORTH

Champignons comestibles (*Fungi edules*). By GUILLERMO HERTER. (Paris: Paul Lechevalier, 1951.) Pp. vi + 203, 101 plates and 1020 figures. Price Frs. 1800. (French text.)

In his preface, Dr Herter tells us about the immense energy he expended in his efforts to popularize the larger Fungi as articles of diet in Central European countries twice ravished by world wars. The atlas under review was born of these efforts. Most of the species here represented by black and white drawings are well known in this country. The most notable exception, as always in a book of this sort published on the Continent, is *Amanita caesarea*. Of the 101 species there are about fifty-seven gill fungi and sixteen species of *Boletus*. Puff-balls, brackets and the larger Ascomycetes are allocated some half-dozen species each. Four kinds of truffles are given. Other genera include *Fistulina*, *Hydnum* and *Clavaria*. In almost all cases the species are those that would be chosen from any European country.

Each species is represented by several drawings showing different stages of development, different aspects, etc., and where necessary, a section through the whole fungus is included, all half natural size. Microscopical characters are not depicted, except the spores to the scale of × 1000.

The accompanying text gives the author's view of the correct scientific name (double citation with date), the 'indispensable synonomy' and a selection of French and German popular names. The descriptions which follow are short, terse and along the usual lines, technical terms being avoided as far as possible. Apart from spore shape and measurements, microscopical characters are not given. Chemical reactions receive no mention, not even an iron salt for the genus *Russula*. Finally, we are given brief notes on habit, habitat, time and frequency of appearance and gastronomic properties, the latter including an occasional hint on preparation for the table. In a few instances, a warning is given of certain species with which the particular one under consideration might be confused.

At the end of the book there is a systematic table of species figured, a bibliography of some 150 titles and an index of popular and scientific names.

No generic characters are given, nor are there any introductory remarks on the way by which species of toadstools are distinguished. There is no glossary of such technical terms as are used. It may, however, be argued that this information has no place in an atlas.

The printing and paper are good, but the binding is poor, and the atlas is too big to put into the ordinary male-size pocket.

In a note on the figures, Dr Herter says they depict (*représent*) the interpretation of some thirty authors whose names he gives: from Barla, Berkeley and Boudier to Julius Schaeffer by way of Cooke, Fries, Herter and Lange. This, taken in conjunction with the fact that I recognized some of the drawings as having been previously published by one or other of the thirty authors mentioned above, seems to indicate that the atlas is of the nature of a compilation. Thus, some of the figures on Plates 8 and 28 are re-drawn from Jakob Lange's *Flora Agaricina Danica*; the spore of *Tuber magnatum* (Plate 101) is from Malençon's *Monograph*. No indication is given on any of the plates of the source of the drawings, so it is not possible, without a great deal of labour, to say how many of the drawings are new.

Within the limitations entailed by the absence of colour, the drawings may be said to be passable. But the absence of colour is a serious defect in a book presumably published, like the fungi it recommends, for popular consumption. This defect seems to have been appreciated by Dr Herter, for we are referred in his preface to the bibliography 'que l'on peut consulter avec profit pour trouver les couleurs des espèces'. With a bibliography of about 150 titles, this sort of bulk reference is not very helpful. But real help is at hand, for the final paragraph of the preface mentions Maublanc's two little volumes: *Les Champignons de France* which is described as being 'assez complet'. Dr Herter does, in fact, refer to one of Maublanc's coloured plates (of which there are 224) wherever possible. Examination shows that only about fifteen species in the atlas are not represented by coloured plates in Maublanc. I, for one, would willingly forgo the gastronomic delights of those fifteen species in favour of Maublanc's volumes, which moreover, fit so nicely into the male-size pocket.

Dr Herter is no newcomer to toadstools nor, for that matter, to other branches of Botany as the impressive list of titles 'du même auteur' on page ii clearly indicates. It is all the more remarkable, therefore, that he should side with those mycologists who ignore Art. 20 (*f*) of the International Rules of Nomenclature.—He tells us that he was compelled to find the scientific name for each species according to the principle of priority, taking Linnaeus's *Species Plantarum* (1753) as the starting point. The result of this is that we are presented with some startling binomials and new combinations. Thus we have *Coprinus porcellanus* for *C. comatus; Marasmius caryophylleus* for *M. oreades; Tricholoma triste* for *T. terreum; Armillaria obscura* for *A. mellea;* and there are others. *Elvela* and *Elvelaceae* are thus spelt necessitating the reduction of *Helvella crispa* Fr. 1822 as a synonym for *Elvela crispa* (Scop.) Hert. 1951. (A reversion to *Helvellaceae* occurs at the top of page 176.) It is a good thing that the author has included the synonomy. It is quite indispensable.

There do not seem to be many misprints, but in the bibliography Hervey, R., should read Henry, R.

F. BAYARD HORA

Puffballs and their Allies in Michigan. By ALEXANDER H. SMITH. (Ann Arbor: University of Michigan Press, 1951.) Pp. xii + 133, 43 plates. Price $ 3.00.

The scope of this attractive and handsomely produced little book is accurately defined by its title. It is a local Gastromycete flora containing adequate, easily understandable descriptions of eighty-seven species, varieties and forms recorded as occurring spontaneously in the State of Michigan in the United States of America. Seventy are described afresh from the author's personal collections or from other collections at his disposal; diagnoses of the remainder have been compiled mainly from the works of Routien, Coker and Couch, and Zeller and Dodge. The numerous photographs have been carefully selected to illustrate the macroscopic features of fifty-seven of the fungi involved and are probably adequate supplements to the carefully planned keys to species in the text.

Dr Smith is well known as a student of North American Agaricales, and on them he writes with confidence and authority. In dealing with Gasteromycetes he is clearly on less familiar ground or even sometimes ill at ease, so much so that he sometimes allows his own judgement to be overridden by the published statements of earlier authors. In planning the book he has adopted Zeller's classification bodily and copied the diagnoses of families and genera verbatim from the latter's paper in *Mycologia*, 1949, even where they conflict with his own observations. Thus on p. 122 we read that the families of Podaxales are:

I. Gleba not powdery at maturity . . . . Secotiaceae
I. Gleba powdery at maturity . . . . Podaxaceae

but at the foot of the page is the contradictory note: 'The Secotiaceae is the only family of this order in Michigan and its members will be found to have a powdery gleba at maturity.' The book contains one new name, *Geastrum fimbriatum* f. *pallidum* n.f. and British readers will also encounter a number of unfamiliar epithets of common species, due to the application of the International Rules of Nomenclature. Thus the familiar name *Calvatia caelata* is replaced by *C. bovista* (Pers.) Kambly & Lee, while *Crucibulum vulgare* figures here as *C. levis* (*sic*) (DC.) Kambly & Lee. Both combinations are cited from an obscure American publication not available at Kew, and the case for the second is evidently debatable. Authorities have differed about the interpretation of *Cyathus levis* DC., and unless its identity can be established beyond doubt it seems a pity to reject the well-established name *Crucibulum vulgare* Tul. merely because, as we are somewhat oddly informed, 'the epithet *levis* must be accounted for' (p. 121). Only thirty-eight of the fungi described are as yet known in Britain, though it may well be that careful search may reveal on this side of the Atlantic some of the very minute species detected by Routien. It is interesting to note that the *Lycoperdon umbrinum* Pers. complex is apparently as difficult to define in North America as in Europe. Collectors of folklore may be surprised to learn that *Dictyophora duplicata*, which smells like a *Phallus*, has been worn inside a countryman's cap as a cure for rheumatism. On the whole, however, we feel that, though likely to be a very successful and popular local handbook, this venture offers little that is new to serious students of Gasteromycetes outside Michigan.

R. W. G. DENNIS

The 'Agaricales' (Mushrooms) in Modern Taxonomy. By ROLF SINGER. (*Lilloa*, Tome XXII. Published by the University of Tucuman, Argentine, 1951.) Obtainable from Chronica Botanica Co., Waltham, Mass., U.S.A., $6.75.

This is a very remarkable book, and however much we may disagree with the author, it will hold an honourable place on our bookshelves. The book has 832 pages and represents a vast amount of work. The early part consists of a critical survey of the present taxonomic position of the Agaricales among which the Boletaceae are included. Several aspects of the subject are dealt with: new methods of diagnosis, chemical reactions, stains, cytology, problems of nomenclature, etc. The author discusses the various hypotheses regarding the derivation and evolution of the agarics which he considers very much an open question. All this leads up to the main purpose of the book which is to provide a new classification of the agarics and boleti. Dr Singer has made two previous efforts at such a classification but this time his work is based on a much greater mass of material and a much wider geographical range. In his own words: 'the vast majority of data contained in this book are based on the author's own investigations, including the insertion of every single species at its proper place in the classification'. It would almost seen that he had pulled to pieces specimens of all the known agaric species of both hemispheres and placed each one in its appropriate niche, one specially designed by himself to which his name is duly attached. Indeed the name Singer is so often repeated, that it fills up an appreciable portion of space on each page. He indicates where keys to species are available and often supplies such keys himself, a feature of the work we shall find very useful. There is an index to species and one to genera but not to subgenera though he has introduced a large number of these. Long descriptions of each genus are given, too long perhaps, but fortunately shorter diagnoses giving essential features are available in his keys to genera.

Dr Singer pays due tribute to the pioneers in the modern study of the agarics; also to many contemporary authors, especially those of the French School whose critical work he often, quite rightly, embodies in his own system.

This is not the time for a detailed appraisal of what can only be termed a revolutionary work in the field of taxonomy. It will find its level in the process of time. Much will be rejected but much will remain to justify the author's attempt to build a new and elaborate frame-work to replace the simpler structure which has served its purpose for more than a century. Incidentally we are fortunate in having it written in good clear English with only occasional and unimportant lapses. This, in itself, is a considerable feat from one not writing in his native language. A. A. PEARSON

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The terms approved by the Council for the administration of these Bequests provide for financial help by the allocation annually of grants to enable one or more students of mycology to attend the Autumn Foray or Plant Pathology Field Meeting, who would otherwise be unable to do so. Applications from students or recommendations from Heads of Departments or members of the Society should reach the Secretary, or the Secretary of the Plant Pathology Committee, not later than 1 May each year.

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INSTRUCTIONS TO AUTHORS

Contributors are asked to be clear and concise, and to use a recent issue of the *Transactions* as a guide to the arrangement of headings and subheadings, explanations of plates and figures, references to the literature, and other details. Each paper should start with a short summary.

The standards adopted in the *Transactions* are those outlined in the Royal Society's pamphlet, *General Notes on the Preparation of Scientific Papers* (1950, Cambridge University Press, 200 Euston Road, London N.W. 1, price 2*s*. 6*d*.). An exception is that in the *Transactions* citations of references to literature, although based on the Harvard system, include the full titles of the papers and complete page numbers. Titles of journals are abbreviated in accordance with *A World List of Scientific Periodicals*, 1934.

The scientific names of genera and species are printed in italics and should be underlined in the typescript. The title of the paper, headings, and subheadings may be in capitals, but should not be underlined.

The attention of authors proposing new taxonomic groups is drawn to the need to give an adequate description and figure, and to designate the types as required by the *International Rules of Botanical Nomenclature*. The description of a new species should be accompanied by a figure, and whenever possible the type specimen should be deposited in one of the national herbaria.

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